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An Effective Services Framework for Sharing Educational Resources

by

Shanshan Yang

A thesis submitted in partial fulfilment of
the requirements for the degree of

Doctor of Philosophy in Computer Science

University of Warwick, Department of Computer Science

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Declarations

This thesis is presented in accordance with the regulations for the degree of Doctor of Philosophy. The contents of this thesis are a result of my own work, and it contains nothing that is based on collaborative research. It has been composed by myself and no part of the work contained in this thesis has been submitted for any degree or qualification at any other university. Parts of the thesis have been published previously in book chapter, journal and conference papers, as follows.

- Initial ideas in Chapter 1 and Chapter 2

  S. Yang, M.S. Joy, "SOA Services in Higher Education", Proceedings of the 7th International Conference on Education and Educational Technology, Venice, Italy, pp. 145-150 (2008).

- Educational components of the framework in Chapter 3

  S. Yang, M.S. Joy, "Designing E-Learning Services: A Case Study", International Journal of Advanced Corporate Learning, 2(4) pp. 35-46 (2009).

S. Yang, M.S. Joy, "Designing E-learning Services", Proceedings of the International Conference on E-Learning in the Workplace, New York, US, pp. 69-73 (2009).

- Technical components of the framework in Chapter 4

S. Yang, M.S. Joy, "Service Advertisement and Discovery", Book Chapter In: Agent-Based Service-Oriented Computing, Springer, London, pp. 21-46 (2010).

S. Yang, M.S. Joy, T.H. Laine, "An Educational Services Architecture to Share E-learning Resources", Proceedings of the 3rd International Conference on Computer Supported Education, Noordwijkerhout, Netherland, pp. 372-375 (2011).

- Evaluation of the framework in Chapter 5

S. Yang, M.S. Joy, J.R.C. Nurse, "Experiences on Sharing E-Learning Resources Using Service Technologies", Proceedings of the 14th International Conference on Computers and Advanced Technology in Education, Cambridge, UK, to appear (2011).

Abstract

Nowadays, the growing number of software tools to support e-learning and the data they rely upon are valuable resources, supporting different aspects of the complex learning and teaching processes, including designing learning content, delivering learning activities, and evaluating students' learning performance. However, sharing these educational resources efficiently and effectively is a challenge: there are many resources, these have not been described accurately and in general they do not interoperate, and it is common for the tools to rely on different technologies. This thesis explores a solution – a novel educational services framework – to improve the sharing of current e-resources, by applying the latest service technologies in the context of higher education. Our findings suggest that the proposed framework is effective to deal with the technical and educational issues in resource discovery, interoperability and reusability, however, there are still technical challenges remaining for implementing this service framework.

This research is divided into 3 phases. The first phase investigates the sharing of e-learning resources through a literature survey, and identifies limitations on current developments. In the second phase, the current problems relating to resource sharing are addressed by a proposed educational service framework, which contains both educational and technical components. Through a case study, nine e-learning services and their dataflows are identified. To determine the technical components of the framework, a novel Educational Service Architecture is proposed, which allows resources to be better described, structured and connected, by following the principles of discoverability, interoperability and reusability in service technologies. In the third phase, part of the framework is implemented and evaluated by two studies. In the first study, users' experiences were collected via a simulation experiment, to compare the effectiveness of a service prototype with that of the use of current technologies. During the second part of the evaluation, technical challenges for implementing the services framework were identified via a case study, involving the implementation of another service prototype.

Chapter 1

Introduction

This chapter introduces the area our research focuses on and explains why it is important. The research purpose, research questions and methodology, as well as the definitions of technical phrases, are covered.

1.1 Background and problems

Educational resources (or e-learning resources, e-resources for short) refer to e-learning applications and their data that support different aspects of the complex learning and teaching processes, including designing learning contents, delivering learning activities, and evaluating learning performance (Meyer *et al*., 2007). The typical data these applications handle include e-learning materials, assessment submissions and marks (Zhou *et al*., 2009). In practice, e-learning data and applications are mixed and cooperate together, and there are many varieties, as the functions and formats are different in each resource (Bean, 2010). For example, there are different types of e-learning materials, such as slides, videos and web texts, and there are different applications to process them, such as tools to create and modify them, tools to store and search them, and platforms to run them. The sharing of e-learning resources means redistribution, remix and reuse of currently available e-learning applications and their supported data (OKF, 2012).

Nowadays, e-learning has become increasingly popular. The number of software applications and the data they rely upon are growing (Butcher, 2006). These various applications can bring benefits to us, as they provide more options to meet different requirements. The rapid development of the Internet has potential to allow these resources to be accessible online (Su *et al*., 2007). However, sharing these educational resources efficiently and effectively is a challenge: a crucial problem that the field currently faces is that there is not enough sharing going on, hence people cannot fully benefit from these quality resources. There are many e-learning resources available, however they have not been described accurately, and in general they do not interoperate, data cannot be exchanged at all between resources. Furthermore, it is common for the tools to rely on different implementation technologies, which further exacerbates the problem. There is also lack of management of these shared resources, they have not been properly organised and monitored, and for some of them, people are even not aware of their existence (Sun and Fu, 2005).

Below we review the resource sharing issues from both a university angle and a resource angle. Typical examples that are relevant within a university are listed first.

- Data such as students' records cannot be passed around easily between systems in multiple departments and centrally managed university systems.
- A highly recommended learning management system that has been deployed in one department cannot be easily reused in other departments as the technical description of the system may not be available or accurate.
- Teachers cannot discover and reuse quality e-learning materials for their students as they are not aware of other repositories they can use in the UK and elsewhere.
- Although many educational tools have been developed, they have still not been described and organised properly, and some of them are not widely available and accessible for most learners and educators. Making selections to suit each user's needs is not straightforward.

By only considering the sharing of a typical type of resource – e-learning materials – the following problems arise in resource description and discovery.

- Users can only get access to a limited amount of reusable e-learning materials.
- Discovering large amounts of e-learning materials takes a long time.
- It is difficult to choose suitable learning materials.
- It is difficult to select an appropriate learning platform to run these discovered learning materials as the description of such platform is poor, for example the formats of learning materials may be incompatible with certain learning platforms.

It is necessary to develop a solution to redeploy existing tools and their supported content in a more effective, efficient way. Our research explores a solution to improve the sharing of current e-learning resources. Service technologies, in particular the

Service Oriented Architecture and Web Service, which have become popular among academia and industry, offer a potential solution, largely due to their ability to facilitate discoverability, interoperability and reusability. Instead of the traditional methods for system design and coding, service software can be developed by wrapping and reconnecting existing applications (Friday *et al*., 2004).

In this thesis, we explore a novel service oriented framework as a potential solution for these issues, to improve the sharing of current e-learning resources (Chung and Chao, 2007). By wrapping existing educational software as e-learning services, this allows resources to be outwardly described and linked, so that they can be better found, accessed and reused, without much work being required for reimplementation (Erl, 2007).

1.2 Research purpose and questions

The aim of our research is to provide a deeper understanding on the topic of sharing current e-learning resources, by indentifying problems in current practices, developing solution to address them via service technologies, and evaluating how well the problems have been solved via our solution. We have only applied service technologies in this research, to explore how well this technology can cope with better reusing and sharing of current e-resources, developing better e-learning resources is beyond the scope of this research. The main question this research is attempting to answer is:

How to improve the sharing of current educational resources?

Our work is divided into 3 phases and guided by the following 5 research questions:

The first phase is to investigate the development and problems in sharing e-learning resources from the literature – What limitations do we have in sharing current educational resources (RQ1)?

The second phase is to propose a solution to cope with the sharing problems – an educational services framework. This framework contains both educational and technical components. To indentify the educational components – e-learning services and their data flows – we have asked the question: What educational resources should be shared and how to identify them (RQ2)? To indentify the technical components – Educational Service Architecture – we have asked the question: How can identified educational resources be shared (RQ3)?

The third phase is to evaluate our solution from users and service developers' perspectives, to find out that if The sharing if educational resources been improved via our services framework (RQ4)? and What challenges are there while developing educational services (RQ5)?

1.3 The concept of e-learning services

The word 'service' is used in multiple contexts, and there are many definitions. The generic definition of service in dictionaries relates to 'the performance of work (a function) by one for another' (Oxford English Dictionary, 2006). From an industrial perspective, IBM defines a service as 'a provider/client interaction that creates and captures value' (IBM ESB, 2012). In academia, Chung states that 'a Service is the non-material equivalent of tangible goods' (Chung, 2007) which, in this context, can be interpreted as a repeatable task, e.g. booking a hotel room.

Our working definition for a service refers to a repeatable task, offered by multiple providers, which contains functionality that is able to meet users' requirements. Technically, an e-learning service (or educational service) is a software component that is able to exchange educational information with other software components, for the purpose of supporting learning experiences, in heterogeneous environments including the Internet (Yang and Joy, 2008).

In the educational domain, many processes support a university's learning and teaching activities (Hazemi and Hailes, 2002). For example, the process of delivering a module, which might involve tasks such as designing the module, delivering the course content, assessing students, and evaluating students' learning progress (Bierhoff, 2007). Resources support these tasks can be considered as e-learning services, and more than one service may be available to complete each task. Most of these tasks can (in principle) be performed by software provided by different e-learning vendors. Data such as course specifications, learners' information and assignment data are reused and shared within and for communication between these services. The diagram 1.1 below illustrates the relationships between users, requirements, services and their providers.

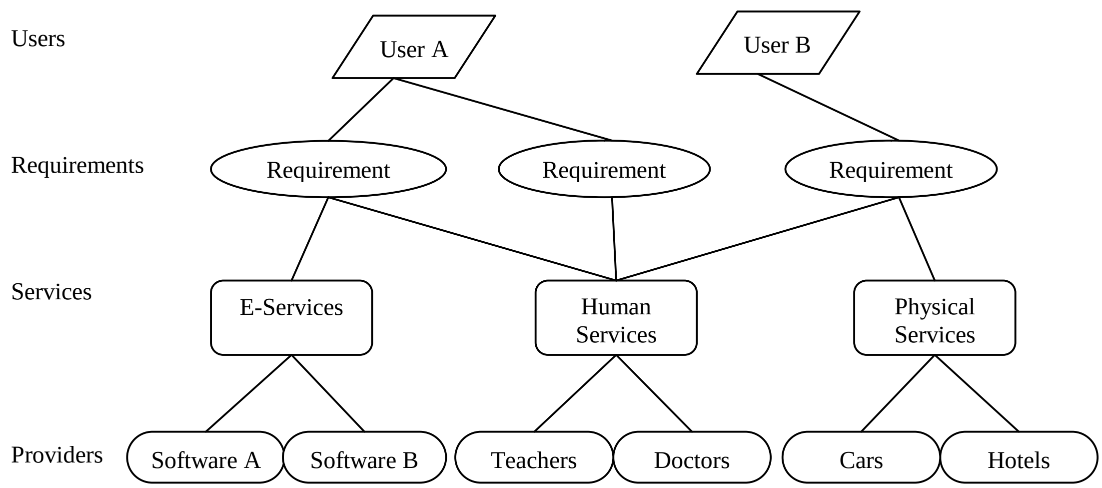


Figure1.1: The concept of e-learning services

1.4 Methodology

Due to the 'proof of concept' nature of our work, by indentifying *what* e-learning resources should be shared and *how* to share them, we will apply qualitative research strategies throughout the thesis (Miles and Huberman, 1994). Additionally, due to the limitations on time, human support and literature resources, we have applied the case study style of research to collect data for research questions 2, 4 and 5. We select a typical UK institution – The University of Warwick – as a single case to focus on throughout the whole research. Our findings would be strengthened and more reliable if we could apply two or more case studies across a number of universities, however, we might duplicate results by doing this, and access in other institutions to research resources, such as staff, students and documents, would be restricted (Yin, 2009).

Research Overview					
Stages	RQ 1	RQ 2	RQ 3	RQ 4	RQ 5
Time	0-12 months	12-24 months	24-36 months	36-48 months	48-60 months
Major achievements	Motivation and sharing problems	Learning and teaching processes and data flows; educational services	Educational Services Architecture	Improvements and limitations on service approach	Challenges in developing educational services
Activities	Content analysis	Content analysis; case study experiment 1	Content analysis; software coding	Case study experiment 2; software coding	Software coding; content analysis
Instruments	Literature review	Literature review; interviews	Literature review	Interviews; questionnaires; Prototypes	Literature review

Table 1.1: Overview of research methodology

Table 1.1 above outlines the research we have conducted. Our work involves research both in technology and education, and contains 5 stages, each one is guided by a research question. In the rest of this section, we will discuss each research question in detail, the research activities we have performed to answer that question, together with the overall achievements.

RQ 1: What limitations do we have in sharing current educational resources?

We have conducted a literature survey to explore the current developments in sharing educational software and their support data. The survey reviews varied educational requirements in the context of higher education, current developments on e-learning resources, together with gaps and weaknesses in sharing these e-resources. These investigations reflect on what is happening, as well as the significant gaps and limitations, in the area of sharing and reusing current e-learning resources, and so motivate us to conduct the rest of research throughout the thesis.

RQ 2: What educational resources should be shared and how to identify them?

This research question focuses on the educational components in our service solution: educational resources could be shared as services and their relationships. Our solution is a novel educational services model that shows how current e-resources can be shared, and a case study has been used to identify these services and their relationships. We have also evaluated current e-learning applications that can be wrapped as services, and standards to represent their supporting e-learning data.

RQ 3: How can identified educational resources be shared?

This research question aims to study the technical components of our service solution, the *educational services architecture*. We first present our proposed architecture with a workflow example, we then discuss the service principles our architecture has followed, and finally we discuss the state of the art on the implementation technologies that could develop educational services and components of our architecture.

RQ 4: Has the sharing of educational resources been improved via our services framework?

In order to evaluate the effectiveness of our proposed services framework from the user angle, we have implemented part of our service framework, to study whether or not our service approach can improve the description and management of e-learning materials within their repositories, and have compared the service approach with the approach that uses current technologies. This study provides direct evidence from users to suggest improvements that the service approach can bring in resource discovery, reusability and interoperability, as well as to suggest limitations of the current prototype.

RQ 5: What challenges are there while implementing the services framework?

In order to evaluate our proposed services framework from a technical perspective, we have wrapped two plagiarism detection tools – JPlag and Sherlock – as educational services. Challenges we have encountered have helped us to evaluate the technical contribution of our proposed services framework, as well as to evaluate how well current service technologies are able to implement our framework.

1.5 Thesis organisation

In order to answer these research questions, our thesis is structured as the followings.

Chapter 2 deals with research question 1, beginning with reviewing the nature of learning and teaching, follow by current developments of e-learning resources and service technologies. This chapter also identifies gaps and problems in sharing current educational resources within existing research, hence provides motivation to conduct this research.

Chapter 3 describes the findings from experiment 1, where research question 2 is considered. We have indentified a set of e-learning resources that can be shared and reused within a typical educational institution via a case study. The experiment design, the methodology we have applied, as well as the findings, are presented.

Chapter 4 covers the development of the technical components of our services framework, to cope the limitations on resource discovery, reuse and interoperability. Research question 3 is addressed. We reflect on the implementation technologies that develop the e-learning services and the components of our architecture

Chapter 5 is the evaluation chapter, and answers research question 4. We have conducted our second case study experiment, which contains three distinct research phases, and the methodologies and findings are discussed. Evidence has been collected to support the advantages and disadvantages of our proposed service approach as well as the current approach.

Chapter 6 is another evaluation chapter, it aims to indentify technical challenges we have encountered while developing plagiarism detection services. These will suggest the technical contributions that our services framework can bring, as well as limitations on service technologies to implement our framework.

Chapter 7 concludes the thesis and summarises our research achievements and contributions. Further research directions and open questions are then included.

Chapter 2

Literature Review

This chapter provides a foundation for our research, based on a thorough literature survey. It covers the terminologies, general development, limitations and gaps surrounding the area of sharing educational resources, which would motivate our research in later chapters. The concepts and state of the art on web service technologies are also included.

2.1 Educational resources

This section covers the concepts and current developments in educational resources. We first begin with introducing our working definitions of educational resources, and then present the current developments, and consider in turn learning objects and their repositories, learning management systems and e-assessment tools. Finally we evaluate the weaknesses in current research, and highlight the areas we are going to address in later chapters.

2.1.1 Definitions

In the context of educational technology, educational resources (ER for short) are often understood as 'Learning Objects' that are stored in a digital repository as text or video files, which can be reused by many learners and educators. Tuomi (2005) argues that ER actually means something wider, and that educational software and information that are used for discussion, assessments, student support (such as help, feedback and advice) as part of the learning process, could also be viewed as resources. The Organisation for Economic Cooperation and Development (OECD) has also defined ER as 'anything that can be used to organise and support learning experiences', and includes the following components (OECD, 2007).

- **Learning contents:** Materials published for learning or reference, such as courseware in MIT OCW, learning objects in ARIADNE, collections of references in Wikis.
- **Tools:** Software for development and delivery of resources, such as Moodle and Blackboard.
- **Implementation resources:** copyright licenses, design principles of best practices, national or institutional policies, and standards to support interoperability (e.g. IMS, SCORM).

Our research has also considered both open and commercial educational resources. The term ‘Open Educational Resources’ (OER) was first defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2002, as ‘the open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for noncommercial purposes’, for the purpose of ‘promoting access, equity and quality in the spirit of the Universal Declaration of Human Rights’ (UNESCO, 2009). In 2005, The OECD has launched a further study on ER, and further clarified open ER as ‘digitised materials offered freely and openly for educators, students and self-learners to use and reuse teaching, learning and research’. The OECD (2007) has defined an *idea* status of openness, as that ‘the resources should be published in a format everyone can open without having to buy proprietary software’.

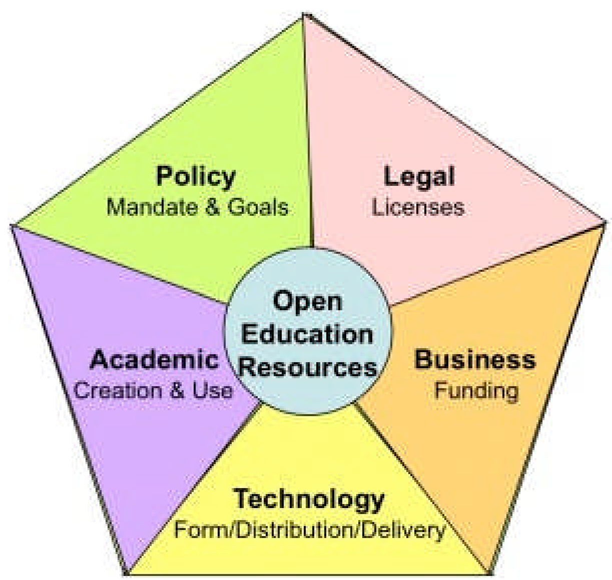


Figure 2.1: Educational resources with other factors (Stacey and Rominger, 2006)

Stacey and Rominger (2006) argued that current open educational resources are also affected by a number of other domains, as shown in Figure 2.1 above. Due to the technical based nature of our research, we are interested in the research and practices of e-learning resources in the domains of education (‘academic’ in figure 2.1) and technology, and have considered educational resources as learning and teaching supported technologies, which are classified as follows.

- **E-learning contents:** these refer to digitised data or information that are accessible on computers for the purpose of supporting the learning experience. Typical examples include learning objects, students’ records, collections of references in Wikis.
- **E-learning applications:** these refer to systems and tools that support daily learning and teaching activities, delivery of learning contents, such as learning management systems and marking tools.

In practice, e-learning data and applications are mixed and collaborate together. Factors like copyright licenses, funding, institutional policies, network connections, computer hardware, are beyond the scope of our research.

2.1.2 Learning objects and their repositories

Learning objects are a typical example of educational resources. These should contain quality material, and together with their repositories form perhaps one of the most widely developed educational resources in the e-learning community. The following are some of the popular ones.

MIT OCW

MIT OpenCourseWare (OCW) was announced in 2001 at MIT, and is the largest project in the US to provide and store online courses. Funding bodies, including the William and Flora Hewlett Foundation and the Mellon Foundation, have spent on average $4.3 million per year to support it. By 2007, over 1,700 US courses have been made available through OCW (Carson, 2006).

MERLOT

Multimedia Educational Resources for Learning and Online Teaching (MERLOT) was developed by California State University in 1997, and funded by the US National Science Foundation. MERLOT is different from MIT OCW as OCW owns and maintains learning contents in its repository, whereas MERLOT only provides the descriptions and locations of learning resources they refer to, hence MERLOT is a typical ‘referatory’. By 2007, it has collected e-materials in 24 universities, 13 professional societies, and 10 digital libraries across North America. Another outstanding feature of MERLOT is that it provides peer reviews on each item of material, similar to those on Amazon. The review criteria include quality of content, potential effectiveness and ease of use (Merlot, 2012).

ARIADNE

Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) is a gateway for the foundation of the European Knowledge Pool. Similar to MERLOT, ARIADNE offers links and descriptions of e-learning materials in various European languages across the disciplines of science and social science, in order to promote collaboration between European educators and learners. The first stage of the ARIADNE European projects is to develop a network of learning repositories across the member institutions in the Netherlands, Belgium, France, Spain and Greece. The ARIADNE II projects aim to develop tools and methodologies to better create, manage and reuse web based educational resources. ARIADNE is alive since a number of ongoing projects are still taking place to develop e-resources in the subject areas of natural history, environmental cultural heritages and agricultural sciences (ARIADNE, 2012).

JORUM

JORUM is a collection of free e-learning contents across all subject areas for both Higher and Further Education in the UK (JORUM, 2012). Materials in JORUM are now able to be discovered through ARIADNE.

OpenLearn

OpenLearn is a repository developed by the Open University in the UK. It has provided 5400 hours of open access learning contents online, and contains two sections: LearningSpace offers materials for learning online, and LabSpace allows contents to be reused and modified further (OpenLearn, 2012).

CORE

China Open Resources for Education (CORE) was established in 2003, after an MIT OCW Conference was hold in Beijing. By 2007, 12 leading Chinese-speaking universities and other 210 member universities had made 750 courses available online. At the beginning, the CORE project was involved by translating MIT OCW materials to Chinese and made them available within Chinese universities. Since 2006, the main focus has shifted to help member universities to publish their own OER and bring Chinese contents to the rest of the world. Discussions are going on in the translation process because of ‘the cultural and pedagogical differences’ between the east and west (CORE, 2012).

Tables 2.1a and 2.1b below summarise the repositories we have discussed. The entries in the table refer to the information *publicly* advertised on the relevant web sites, since we are concerned with a user perspective on the type and availability of material in the repositories, and we can reasonably assume that the user is English speaking. As we can see, not all the information is publicly available to describe each category for each repository, and they are still very difficult to compare.

Some entries are still ‘unknown’, for instance, ARIADNE has not covered the subject area on each learning material they have collected at the moment. Similarly, the material type for OpenLearn is still not available yet, and most e-learning content in

CORE is just described in Chinese. Of course, these ‘unknown’ entries can be filled in by enquiring directly from the repository managers, or translating the website in the case of CORE, but a user would be unlikely to do so.

Some entries are difficult to compare. For example, considering the material type for ARIADNE, it is unclear why so many types are listed. Does it mean that ARIADNE has more e-learning content than other repositories, or is it that the classification is more fine-grained? Poor descriptions of these repositories have prevented many people from discovering, understanding and comparing the materials there. Hence, it could be difficult for many users to select the suitable resources to use or share, as the similarities and differences between them are not obvious.

Table 2.1a: Developments on learning objects and their repositories

Learning objects and repositories	Location	Languages	Subjects	Material Type
MIT OCW	US	English, Spanish, Portuguese, Thai, Persian, Turkish, Chinese, Korean	Business, Energy, Engineering, Fine Arts, Health and Medicine, Humanities, Mathematics, Science, Social Science, Society, Teaching and Education	Lecture notes, reading lists, problem sets, video, audio lectures, projects, labs, assignments, tools, animation.
MERLOT	US	All	Academic Support, Arts, Business, Education, Humanities, Mathematics and Statistics, Science and Technology, Social Sciences, Workforce Development	Assignment, case study, ePortfolio, learning object, journal article, open-textbook, presentation slides, quiz/test, simulation, tutorial, workshop and training material.
ARIADNE	West Europe	All	Unknown	Image, presentation, web page, reference material, activities and labs, lesson plan, text, simulation, course, tutorial, homework and assignments, video lectures, exploration, glossary, teaching and learning strategies, audio lectures, open textbook, exercise, experiment, assessment, educational game, case study, animation, journal article, questionnaire, quiz/test, learning object, textbooks, demonstration, project document, ePortfolio, articles and reports, discussion forums, blogs and wikis.

Table 2.1b: Developments on learning objects and their repositories

Learning objects and repositories	Location	Languages	Subjects	Material Type
JORUM	UK	English	Architecture, Biological Sciences, Business, Arts and Design, Languages and Literature, Education, Engineering, Historical and Philosophical studies, Law, Linguistics, Mathematical and Computer Sciences, Medicine and Dentistry, Physical Sciences, Social studies, Medicine, Technologies, Veterinary Sciences, Agriculture et al.	Simple text files, references to external contents, learning objects, content packages, open courseware
OpenLearn-Learning Space	UK	English	Arts and Humanities, Business and Management, Childhood and Youth, Computing and ICT, Education, Engineering and Technology, Environment, Languages, Law, Mathematics and Statistics, Psychology, Social Science	Unknown
CORE	China	Chinese English	Unknown	Unknown

2.1.3 Learning management systems

The learning management systems, which support the development and delivery of e-learning contents, are also actively under development, and have become increasingly powerful. Some typical ones are presented below.

Moodle

Moodle is one of the most popular Open Source learning management systems, which was originally developed by Martin Dougiamas to support e-learning activities. It contains features for e-assessment submission, markings, online discussions, online quizzes and Wikis. It also supports different formats of learning and assessment materials, such as SCORM and IMS QTI (Moodle, 2012). According to the provider's specification, institutions use it as platform to conduct their full online courses, or to support part of their daily face to face courses (known as blended learning).

Sakai CLE

Sakai is another well known Open Source LMS. It includes many of the features common to LMSs, such as document authoring and delivery, assignment upload, online testing, marking, discussion, and live chat. This software tool is expanding its collaborative learning features for research and group projects. Sakai is a Java-based application which was released in 2005, and by 2008, over 250 institutions across the world had experienced this product (Sakai, 2012).

Blackboard

Blackboard is another popular course management system, developed by Blackboard Inc., however it is not an Open Source product, and there is a lack of documentation to describe it so far. Similar to Moodle, it also supports online learning, online assessments, as well as online communications like chatting and discussions (Blackboard, 2012).

Table 2.2 below briefly compares the LMSs we have mentioned from a technical perspective. Again, each resource is different, and not all of the information that describes these systems is discoverable from the providers' websites, for instance, how each LMS can integrate with other e-learning applications if needed, whether any documented API has been provided, or whether there is an available adapter which can be plugged in to enable system integration.

Learning management systems	Fee	Installation	E-learning standards
Moodle	Free	Installed on local servers	SCORM IMS standards Local standards
Sakai	Free	Installed on local servers	IMS standards Local standards
Blackboard	Commercial	Installed on local servers or hosted by Blackboard	Local standards

Table 2.2: Developments on learning management systems

2.1.4 E-assessment tools

ASSET

ASSET is an e-assessment tool developed by the University of Reading. It aims to allow staff to record video media to provide feedback on their students' assignments. However, the videos are designed for a group of students in general, rather than for individuals (Asset, 2012).

OpenMark

OpenMark is a marking system developed by the UK Open University. The main feature of this tool is providing marks and feedback on written assessments. Each student can also have multiple attempts, so that if their first answer is incorrect, they can have an immediate second, or third attempt, and this behaviour is configurable (OpenMark, 2012).

BOSS

BOSS is an Open Source submission tool that allows students submit their assignments online and allows staff to mark submissions and manage their students' learning records efficiently. The software also supports the marking of computer programming assignments (Joy *et al*., 2005).

Sherlock

Sherlock is an Open Source plagiarism detection application that determines similarities between essays and computer source code files. It is available as part of the BOSS Online Submission System or as a stand-alone application (Sherlock, 2012).

Turnitin

Turnitin is a commercial plagiarism detection tool that can check for the originality of essays against material on the Internet. The provider has stated that it can not only be used to check for students' submissions, but also to suggest students how to avoid plagiarism and improve their writing in the future (Turnitin, 2012).

As with other e-resources, there are similarities and differences between each E-assessment tool. However, in terms of comparing them, again, most resources have not been properly described, and the assignment formats each tool can accept and the internal processing that takes place are not generally available. Even basic information, such as the costs for using each of these tools, are still not clearly advertised on the vendors' websites (see Table 2.3).

E-assessment tools	Task	Fee	Feature
ASSET	Marking	Free	An application that provides video feedback to students' assignments in general
OpenMark	Marking	Free	An interactive tool that that provide text feedback to individual student's assignments
Boss	Submission	Free	An online tool to submit and manage students' assignments
Sherlock	Plagiarism detection	Free	A plagiarism detection application to discover similarities between students' assignments
Turnitin	Plagiarism detection	Commercial	A plagiarism detection application to discover similarities between students' assignments

Table 2.3: Developments on e-assessment tools

2.1.5 Evaluation of current educational resources

To our knowledge, limitations remain on the descriptions of current educational resources: most e-resources have not been described and compared properly (Liu and Fan, 2007; Kashfi and Razzazi, 2006). Hence, it is difficult for users to discover, understand and choose them.

As we have mentioned earlier, in principle, most e-resources are useful to meet varied users' needs, however, each type of resource contains its own features, and there are similarities and differences amongst them (as we have illustrated in tables 2.1, 2.2 and 2.3). Currently, there is not enough information available to describe each e-learning resource. For example, missing or unclear information includes accepted formats for processing assignments in the e-assessment tools (see Table 2.3), and the material types in repositories OpenLearn and CORE (see Table 2.1). More fundamentally, potential users may not even know these resources exist at all.

Even if information is available to describe resources, it may be difficult to compare them. For instance, there is information available to describe types of materials contained in each repository, however, different repositories use their own words, some users might wonder how the ‘problem sets’ in MIT OCW are different from the ‘workshop and training materials’ in MERLOT or the ‘activities and labs’ in ARIADNE (see Table 2.1). Hence, it could be difficult for users to choose the resources to use, as the similarities and differences amongst them are not obvious.

Even if meaningful information is available to describe current e-resources, the suitability for different types of users may not be clear. Educators and learners might be interested in the educational values of these resources, such as the topic area each tool can support, levels of difficulties, previous user feedback, and so on. Resource developers and educational administrators might be interested in the commercial and technical aspects of these resources, such as the cost to use the plagiarism detection tool Turnitin (see Table 2.3), how an LMS such as Moodle can be installed in their own university, and how an LMS can integrate with other existing systems within their university (see Table 2.2).

Management of current e-resources is poor, and current educational resources are not well organised. We have classified them in three categories in sections 2.1.2, 2.1.3 and 2.1.4, but other types of e-resources exist. We next consider how we should organise e-resources to suit different peoples’ needs, but before we start, we need to understand what the users’ requirements are. This leads us to consider the following issue: lack of an available mechanism to map existing e-resources to the varied requirements that support the users' learning and teaching experience (Arch-int *et al.*, 2005). We will cover these in Chapter 3.

2.2 Service technologies

Service technologies have potential to support the discovery, reusability and interoperability of current educational resources (Ren *et al.*, 2010). This section introduces what service technologies are about, and discusses current developments and applications.

2.2.1 The concepts

Service Oriented Computing (SOC) and its enabling technology Service Oriented Architecture (SOA) have become popular among academia and industry (Huhns and Singh, 2005). They represent a new paradigm for software development: instead of the traditional way of system design and coding, the service software is developed by reusing and reconnecting existing applications (Wang *et al*., 2004). SOA is 'a system architecture in which a collection of loosely coupled services (individual software components) communicate with each other using standard interfaces and message exchanging protocols' (Tsai *et al*, 2007). Software components are grouped as services which can be dynamically discovered and integrated over a network to achieve a common task or process (Yang and Joy, 2010).

In an SOA, all functions are packaged as Services (Nokano *et al*., 2007). Services are software components (Sauders *et al*., 2006), and the key building blocks for a system (Chen and Huang, 2006). They might be distributed over a network (Jia *et al*., 2007), and be able to communicate and work collectively to support a common task or process (Chen and Huang, 2006). A service is 'a bound pair of service interface and service implementation' (Liu *et al*., 2007). The implementation implements the service's function (Sauders *et al*., 2006), and the interface enables the interoperability between the services and users. The interface describes what the service is, using a standard definition language such as Web Service Description Language (WSDL), reads the users' and/or other services' requests and sends the responses back to them, and considers security issues while communicate with users and other services (Bierhoff *et al*., 2007).

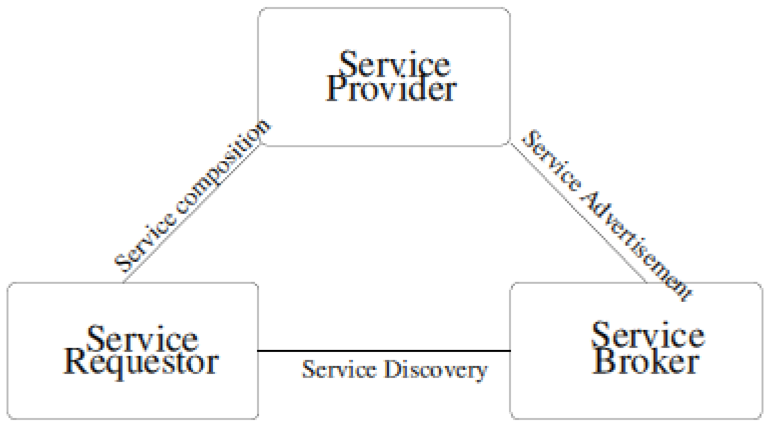


Figure 2.2: Service oriented architecture (Yang and Joy, 2011a)

Most authors consider that a basic SOA consists of three different entities: service providers and requesters and a service broker (registry), and the relationships between these entities are illustrated in Figure 2.1. Dustdar and Treiber (2005) identify the role of the service provider as one of providing descriptions, and that of the broker as publishing them. The requester contacts a broker in order to locate a suitable service to fulfill a given task, and when an appropriate service has been identified, the broker will additionally provide information about how that service can be invoked. The broker uses a services registry (repository) to store the necessary information about services, allowing both user searches and the publication of service descriptions. Searching for and locating services, in order to identify matches between service requesters and providers, is regarded as a key issue, and service brokers (or registries) play a major role in this task. Thus the role of the service broker and its registry is central to the current model of service oriented architecture (Degwekar *et al*., 2007).

It is commonly agree that an SOA implements the following principles:

- *Discoverability* means that information about each application is described and stored in a service registry, so that potential users are able to search and compare available systems by querying the registry (Lucia *et al.*, 2008). Advertising service information is normally considered at the same time as service discovery. Current research in service discovery focuses on how services are described, or specified, or published from a technical view, such as what standards people should adopt, or what architecture could be used effectively (Papazoglou and van den Heuvel Heuvel, 2007).
- *Interoperability* refers to the ability of multiple systems to operate with each other, using different technologies, platforms and programming languages. Inter-system communication is based on standard message exchange mechanisms supported by service technologies (Erl, 2007).
- *Reusability* means that a given functionality within a system can be called many times and in different contexts without reimplementation (Catherall, 2005). Service technology allows existing systems to be better shared, hence making them easier to reuse (Zhou *et al*., 2009).
- *Composability*: Service composition deals with combining small services into larger ones to meet a specified goal (Verjus and Pourraz, 2007).

However, in order to study the sharing of e-resources, our research focuses on the first three principles only, and although service oriented technologies can also support other principles such as composability (Catherall, 2005), applying such principles is beyond the scope of this research. We will discuss how the first three principles are applied in e-learning in Section 4.3.

2.2.2 Features of services

Services can be viewed as repeatable tasks with functionality within a specific process (Quartel *et al*., 2007), and Bloomberg states that a service is 'a chain of value creating activities or events, which forms a process' (Blomberg and Evenson, 2006). It is commonly agreed that all services should be 'well defined' (Nokano, 2007) and the following is a list of their core features (Yang and Joy, 2009).

- *Self contained* (or *coarse grained*). A service 'maintains its own state' (Jia *et al*., 2007), services are 'independent of the state or context of other services' (Papazoglou and van den Heuvel, 2007), and 'other has no control or authority over them' (Verjus and Pourraz, 2007). A service can be accessed from any operating platform, using any appropriate communication device or programming language (Tsai *et al*., 2007).
- *Loosely coupled*. Loose coupling can be interpreted as a way that a user communicates with the services which does not depend on the implementation of the service (Mohammad *et al*., 2006). It also means that new services can be added and existing services can be upgraded depending on the users' requirements. Lukichev (2007) notes the importance of developing loosely coupled components, and loose coupling is seen as a significant service feature (Jia *et al*., 2007, Tsai *et al*., 2007).
- *Accessible*. In an SOA, services are offered by varied service providers, and may be distributed and accessible over a network (Nakano, 2007). Furthermore, non-networked applications can be converted into networked services (Papazoglou and van den Heuvel, 2007), and the network could be either local or Internet based (Mohammad *et al*., 2006).
- *Discoverable*. Services can be dynamically found, composed and replaced at runtime (Jia *et al*., 2007, Papazoglou and van den Heuvel, 2007, Liu *et al*., 2007).

- *Interoperable*. This is about exchanging messages between services. Many definitions exist – for example, Janssen defines it as ‘the ability of two or more systems or components to exchange information and to use the information that has been exchanged’ (Marijn and Hans, 2007), and O’Brien stresses the need for communicating entities to operate on shared information ‘according to an agreed-upon operational semantics’ (Mohammad *et al*., 2006). It is commonly agreed that interoperability is one of the unique features for services, and is arguably essential (Martin *et al*., 2007), and message exchange is also considered as core (Katsionis and Virvou, 2008).
- *Reusable*. This refers to the ability for services to be recalled repeatedly in order to lower costs and increase efficiency. This feature is regarded as an important advantage and exists in many service descriptions (Dustdar and Juszczyk, 2007).

2.2.3 Service standards

Web service technology is one of the most well known technologies to implement a service-oriented architecture. It is commonly agreed that three basic standards are currently in use for web service discovery, interoperability and reusability (Campo *et al*., 2005), each with its own specific role:

SOAP: Communication – how services can be used
WSDL: Description – how services can be published
UDDI: Discovery – how services can be discovered

Fundamental to the efficacy of these standards is the use of a common communications language (Singh and Huhn, 2005), and XML is used by each. The communications protocol is defined by SOAP, and WSDL includes support for passing information about functions supported by services, including their names, parameters and result types. UDDI specifies the contents of the registry, enabling users to search for services and find sufficient information for their deployment – an essential prerequisite if web services are to be meaningful. These standards have been developed by organisations including the World Wide Web Consortium (W3C) (SOA, 2012), OASIS (OASIS, 2012) and the Open Group (OG, 2012) since 2000.

SOAP

In the context of web services, SOAP (Simple Object Access Protocol) is regarded as the standard message protocol for exchanging XML data over the Internet. SOAP is a stateless paradigm which enables complex interactions between services through request/response exchanges and other unidirectional messages. However, SOAP lacks support for the transmission of semantic data, such as routing and firewall traversal (Curbera *et al*., 2002). A SOAP message is essentially an XML element with two XML child elements, a head and a body. These contain descriptions of the message content and how to process it, encoding rules (for application-specific data types), and the representations of remote procedure calls and responses. This information is then wrapped into an envelope, and is bound to a transport protocol for the purposes of the actual information exchange. The following (Figure 2.3) is an example of a SOAP message for invoking a web service for getting a stock price, which is cited from the W3C School website (WS, 2012; Verma *et al*., 2005).

```
<?xml version='1.0'?>
  <soap : Envelope
     xmlns : soap= 'http://www.w3.org/2001/12/soap-envelope'
        soap: encodingStyle= 'http://www.w3.org/2001/12/soap-encoding'>
         <soap:Body xmlns:m= 'http://www.example.org/stock'>
             <m: GetStockPrice>
               <m: StockName>IBM</m: StockName>
             </m:GetStockPrice>
         </soap :Body>
   </soap : Envelope>
```

Figure 2.3: A sample of SOAP (WS, 2012)

WSDL

WSDL (Web Service Description Language) formally provides a model for describing interfaces for web services (Degwekar *et al.*, 2007). A WSDL description specifies the location of the service, the operations for invoking and consuming the web service, and supports binding for defining message formats and protocol details. The following (Figure 2.4) is a typical structure of a WSDL document, which is cited from W3C School (WW, 2012; Curbera, *et al*., 2002):

```
<definitions>
  <types>definition of types</types>
  <message>definition of a message</message> <portType>
    <operation>definition of a operation</operation> </portType>
  <binding>definition of a binding</binding> <service>
    <port>definition of a port</port>
  </service>
 </definitions>
```

Figure 2.4: A sample of WSDL (WW, 2012)

A typical WSDL document contains the following elements. The type element specifies the complex data types for a message, which describe the data being communicated between the web service and the requester. A set of messages and their directions (input or output) form the operations the service exposes. A set of operations then forms a port type, for each of which the concrete protocol and data format specifications are referred to as a binding. The association of a network address with a binding defines a port, and a collection of ports defines a service. In a single WSDL file multiple services can be described (Bean, 2010).

WSDL defines services as ‘collections of network endpoints or ports’. The abstract definitions of messages and the endpoints/ports are then separated from their concrete implementation, such as protocols and data formats, allowing for reuse of those definitions (Chakraborty, 2006).

UDDI

UDDI (Universal Description, Discovery and Integration) is a registry of web service descriptions, allowing users (such as businesses) to publish descriptions of themselves and their services (together with technical information about service interfaces), and clients (such as customers) to identify appropriate service descriptions and create bindings to them (using SOAP) (UDDI, 2012). Wang *et al.* (2004) summarise a UDDI registry as being 'similar to a CORBA trader and can be considered as a DNS service for business applications'. It serves as a generic data model for providing detailed web service specifications including business entities, technical access information, natural language descriptions, keyword-based classification scheme and relevant technical specifications (Curbera *et al*., 2002).

The initial idea of maintaining a central registry for publicly available web services by large vendors, such as IBM or Microsoft, has been abandoned because a single repository cannot meet all the needs for different specific SOA systems (Yu, *et al*., 2006). Version 3 of the UDDI specification is over 400 pages long and contains over 300 function calls. This complexity (for end users) has led to the closure of the public UDDI Business registry and has hindered its widespread adoption, and has led to speculation that future registries will be private (Wu, 2007). As Chappell (2002) remarks: 'the public registry UDDI is too complex for end users since UDDI specification is more driven by its primary members than feedback from the real world end users'. However, Baresi and Miraz (2006) also suggest that the central registry will continue to be important since not all companies will have the facilities for servicing requests locally, and Wu (2007) considers that 'most private registries would focus on a specific, closed domain'.

Both private and public registries follow the two principals of UDDI specification relating to the composition, structure and operation of a registry — the information provided about each service (including its encoding) and an API specifying how to update the registry and how to make queries. The information encoded by UDDI is of three possible types — white pages (names, contact information), yellow pages (categories of information based on service types) and green pages (technical data) (Curbera, 2002). A recent development is UDDIe, an extension to UDDIe which incorporates service leasing and replication. UDDIe includes the ability to search for services based on blue pages (user defined properties associated with a service). Support for service leases, by which a service is restricted to storage in the registry for a limited period of time, enhances the dynamic capabilities of the registry (ShaikhAli *et al*., 2003).

2.2.4 Service applications in different domains

In addition to e-learning, service technologies have been applied in a number of domains, including biomedicine, government and business (Kontogiannis *et al*., 2007).

Some researchers have studied the idea of sharing resources using service technologies. For instance, Zheng and Bouguettaya (2005) have suggested applying ontologies and services to describe biological systems. Gonzalez and Balasooriya (2007) have stated a number of technical problems while they are attempting to share biomedical resources. Janssen and Scholl (2007) have suggested that interoperability between governmental organisations needs to be improved. Web services can cope with this at a technical level. However, social, legal and political factors might affect the practices.

Technologies have been developed to share resources using service technologies. For example, Caceres *et al.* (2006) have proposed a technical approach to describe the semantics of each healthcare application, in order to support the discovery of healthcare services. Vittorini *et al.* (2007) have proposed a service to analyse biomedical data among health information resources, and Zhang *et al.* (2004) have proposed a service framework to share e-payment systems. Matsunaga *et al.* (2007) have proposed a technical framework to link e-government systems together as services, and have mentioned benefits of having this, including saving time, cost, ease of modifying applications, and knowledge of services not required by users.

Research in business services is more advanced (Krishnan and Bhatia, 2007), and instead of service description and discovery, most of the work is related to technologies to support service composition, to cope with the changes of dynamic business processes (Chen and Huang, 2006). For example, Xiao's approach (2007) on change impact analysis for business applications, Dai and Liu's service framework (2006) to link dynamic collaborative applications in e-business environments. Bertoli and his colleagues' approach (2007) focuses on support business service composition, as does Zimmermann's approach (2005).

2.2.5 Cloud computing

Cloud computing is another popular technology that has received lots of interest in academia and industry after web service technologies had been introduced. It uses the Internet (all that a user needs is a Web Brower) to allow users to simply access to different types of computing resources (we name them *services* now), including storage space, software applications, and programming environments. It is simple because users do not need to be aware of the underlying infrastructure and location (Furht and Escalante, 2010).

The idea of 'cloud' comes from the use of a cloud-shaped symbol in network diagrams. Cloud computing is a metaphor for the Internet. Currently, there is confusion about what it is, and there is no formal definition of cloud computing that has been widely accepted. A number of definitions have been proposed.

Jeff Kaplan describes cloud computing as ‘a broad array of web-based services aimed at allowing users to obtain a wide range of functional capabilities on a *pay-as-you-go* basis’ with minimum hardware/software investments and professional skills required. Cloud computing is the ‘realization of the earlier ideals of utility computing without the technical complexities or complicated deployment worries’ (Vaquero *et al.*, 2010).

The US National Institute of Standards (NIST) views cloud computing as ‘a model for enabling ubiquitous, convenient, on demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction’ (Sitaram and Manjunath, 2011).

Web service technologies tend to support the description and discovery of computing resources, by providing and publishing each resource’s APIs to the services community, where the input and output data and their relevant supported operations in each resource are properly defined following service standards. However, cloud computing is more interested in the management of these computing resources, in particular the shared data management within the community. Exploration of cloud services is beyond the scope of this PhD research.

2.3 Diversity in education

This section reviews the nature of learning and teaching from the perspectives of both individuals and institutions.

2.3.1 Learning as individuals

Learning and teaching is complex. It varies between individuals in different contexts. A number of theories have been introduced to address the diversity in individual learning, including Constructivism, Learning Styles, and Bloom's Taxonomy.

Constructivism

Constructivists see learning as the results of mental construction. This learning theory is suggested to use to explain various phenomena in adult learning and development, as they view each learner as a unique individual with unique needs and backgrounds. Constructivism also stresses one of the learning principles: 'learners need enough previous knowledge and understanding to enable them to learn new things. They need help making links with new and previous knowledge explicit' (Pritchard, 2005).

Learning styles

Learning styles refer to varied approaches of learning, which are preferred by, or appropriate to, different individual learners. In fact, learning styles are not always fixed, individual learners might adopt more than one learning style in a learning context, and each learner might adopt different learning styles in different learning contexts. This concept suggests that 'teachers should assess the learning styles of their students and adapt their classroom methods to best fit each student's learning style' (Coffield, 2004).

Bloom’s taxonomy

In 1956, Bloom developed a classification of levels of instructional objectives, which is widely considered in understanding the expectations of learning outcomes (Scott, 2003). He identifies six levels of concrete measurements, which are presented below, where knowledge is the lowest level, and evaluation is the highest level (Anderson *et al.*, 2001).

- Knowledge: remember data or information from previous learning materials.
- Comprehension: understand the facts and ideas by translating, comparing and interpreting. States a problem in own words.
- Application: use a procedure to solve problems in new given situation
- Analysis: break information into parts by identifying causes, inferences or distinguishes.
- Synthesis: puts parts together to form a whole meaning or structures.
- Evaluation: make judgments on idea or material, based on criteria and standards.

These concepts have stressed the nature of diversity on learning and teaching. Educational experts argue that learners are different in terms of their backgrounds, the ways they learn, and their expected learning outcomes. These varieties suggest that people’s requirements are different, before, during, and after each learning activities are taken place. Charlesworth *et al.* (2007) also suggest that educators should apply different learning resources to meet different learners’ needs.

2.3.2 Learning and teaching processes within an institution

As we have mentioned earlier (see Section 1.4), the learning and teaching processes we have considered in this research are applicable in higher educational institutions only. In this section, concrete learning and teaching processes are reviewed from research literature and practical handbooks.

In the literature, educational experts have discussed individual learning and teaching processes in depth. For example, Alan Clarke (2001) has mentioned the processes of designing learning materials, learning activities and assessing learning outcomes in his work. Butcher *et al.* (2006) also addressed the processes of designing learning materials and assessment activities. In Biggs and Tang's constructive alignment (2007), the authors have highlighted the need for delivering assessment tasks and learning activities. Inglis *et al*. (1999) and Forsyth *et al*. (1995) have explored the need for evaluating modules whilst they are being taught. Littlejohn and Pegler (2007) have classified the differences between academic and non-academic support. We summarise the processes that people have addressed as follows:

- Design learning materials
- Arrange learning activities
- Arrange assessment activities
- Evaluate the course

We have also studied a number of items of practical documentation across different departments in a typical UK institution – the University of Warwick – as a case study. The key documents include staff handbooks, student handbooks, undergraduate module guides, undergraduate assessment handbooks, tutor handbooks, postgraduate handbooks and others. These handbooks suggest rules and activities students and staff should follow in a variety of departments across the five faculties, including business, computer science, history, economics, and polities. The main daily needs in learning and teaching are highlighted below (DCS, 2005; DPIS, 2006; DH, 2006; WBS, 2007; DE, 2007):

- Designing quality learning and assessment
- Delivering a module
- Assessing coursework

- Supervising projects and dissertations
- Conducting examinations
- Developing skills
- Learning support
- Personal tutoring

However, there are limitations in the current literature, and people have not stated all the major learning and teaching needs. In practice, most research and practical literature have only addressed these processes separately, there are few useful studies which examine how those tasks relate to each other, what educational information has been exchanged between, and how (Yang and Joy, 2009). These have motivated us to gain a comprehensive understanding of educational processes in current practice, in terms of the sequences of daily learning and teaching activates (learning processes) and their data flows. A number of education experts have also addressed this gap. For example, Palomino-Ramírez *et al.* (2008) have discussed the learning flows and data flows problem, and have mentioned that there is not such specification available currently, and that typical e-learning development organisations such as the IMS ‘does not support the dataflow between e-learning tools’ (Charlesworth *et al.*, 2007).

This section has introduced a number of terminologies within these concepts, which are commonly applied in current educational domain, including learners’ previous knowledge, learning and teaching processes, materials, objectives, requirements and so on. These key terms will be referred to later on when we describe and discuss educational resources.

2.4 Sharing educational resources

The sharing of e-learning resources in our research refers to redistribution, remix and reuse of current available educational related data and applications. Our research involves investigating the varieties of educational requirements and learning supported technologies, and providing the best possible matches and/or mappings between them. We argue that the sharing of ER contains 3 stages, the following (Table 2.1) summaries their developments in terms of research, practices and technologies. Texts in grey highlight areas we focus on in particular in the thesis.

Achievements / Trends	Practice	Technologies	Research
Stage 1: Description	Creation of ER, Quality of ER	Specifications to describe ER	Discoverability of ER
Stage 2: Connection	Reuse of ER, Remix of ER	Brokers, standards to link ER	Interoperability of ER
Stage 3: Movement	Copyright, languages, and culture barriers	Unknown	Remove barriers; Introduce new policies

Table 2.4: Developments on the sharing of educational resources

2.4.1 Problems in sharing educational resources

The following issues in resource discovery, reuse and interoperability are highlighted in the literature. We have classified them as below.

Educational problems

There are limitations on the description of current available e-learning resources. For example, JISC's DART project (Ingram, 2006; Bond and Ryan, 2007) has mentioned that, while sharing e-learning materials, the learning objectives are not always described properly, and the resulting services might not be used or discovered appropriately. Another JISC project – CeLLS – has discovered that, for users from other disciplines, it is not easy to understand the deceptions of certain e-learning resources (Charlesworth, 2007). Also, the quality of resources has not been properly included, in particular, most resources lack user feedback (Bond and Ryan, 2007).

Technical problems

E-learning resources are difficult to interoperate, as they rely on different implementation technologies. Different applications require different access characteristics, and may be distributed on different servers across many organisations all over the world. As a result, educational data such as learners' information cannot be exchanged easily between e-learning applications, users cannot be notified about changes or new resources (Charlesworth, 2007).

E-learning resources are not generally searchable. There is currently no accepted 'standard' to describe e-learning resources, although experts have suggested the use of metadata. However, lots of debates and issues are going on regarding resource classification and discovery using metadata (Arch-int *et al*., 2005). Additionally, there is currently no 'mature' technical component to support the searching of e-learning resources as most e-learning resources are not findable using search engines (Charlesworth, 2007).

E-learning data are difficult to be exchanged and reused in other applications. The first problem is that data are not available over the network to be exchanged, and not all e-learning tools are accessible online. Secondly, there is lack of technologies to transfer data between applications, and although there are some tools to support transfer they can only process simple data types, such as strings, rather than complex e-learning data, like learning objects. Furthermore, data may require further processing, such as format conversion. Different applications might accept and process different types of data, for instance, the format for students' e-assignments might need to be converted in order to be processed in some marking tools. Currently, there are few technologies to support the processing of e-learning data (Palomino-Ramírez *et al*., 2008).

Management problems

There are barriers on sharing e-learning resources from an organisational perspective. However, these are out of scope in our research. These include, for example, the legal issues, such as copyrights and ownership, as an organisation might benefit by opening itself up to others, but will wish to protect itself and make sure it is still competitive with others (Yu *et al.*, 2006).

Also, while the sharing of e-learning resources takes place between different countries, people might face some cultural issues, such as language (Xu and Xia, 2010). For example, in the CORE project we have mentioned before, many translators are required to convert the language of the learning content between English and Chinese, however, most translators do not have any educational background, thus raising a number of quality control problems. Another major cultural issue is the national policies, as we know, 'money can buy more access and political power can be used to change institutional constraints' (OECD, 2007).

In order to deal with these problems, we are interested in identifying technologies that have potential to support the sharing of educational resources. We have decided to apply service technologies in our research, as it is the only popular technology we have discovered so far which appears able to share e-resources effectively.

2.4.2 Methods to develop services

Developing a set of services is a challenge. This is currently no commonly agreed approach to developing e-learning services. However, people have attempted and proposed a number of solutions for identifying services in general, and some of the well-known ones are presented below.

SRI-DM

Millard *et al*. (2007) presents the Service Responsibility and Interaction Design Method (SRI-DM), for designing e-learning Web Services, by ‘capturing a scenario as a use-case, factoring this into a set of Service Responsibility and Collaboration Cards, and constructing a Sequence diagram illustrating their interactions in fulfilling the scenario’. They have also included an example on how to create e-assessment services via this approach, which focuses on investigating the processes of developing individual services in e-learning, and there are not too many discussions on the sharing of e-learning resources.

Service interface design method

Feuerlicht and Meesathit (2004) describe a business services design method by ‘identifying elementary business function and converting standard message (document) formats into a set of corresponding service-interfaces’, then ‘applying data engineering principles to refine the interface design’, and showing ‘how data normalization applied to interface parameters can lead to minimization of coupling and maximization of cohesion of service operations’ (Feuerlicht and Meesathit, 2004). They have also included an example on how to create travelling services via this approach based on the Open Travel Alliance (OTA) specification. However, they have not mentioned if this approach can be applied to develop e-learning services, and how.

Tropos

Lau and Mylopoulos (2004) propose a method for designing Web services in business. It is based on 'Agent Interaction and Capability technique', and 'software requirements analyses'. The process is started from stakeholder goals, then analyzes these goals in order to define business processes. The web services are then generated from these processes. They have also included an example on how to create online retailer services via this approach. Both agent and service software development techniques are involved in this approach. Again, they have not mentioned if this approach can be applied to develop e-learning services, and how.

Grounding

Necasky and Pokorny (2008) proposed a method to describe the semantics of web services and their operations via an ontology. They have shown how to use a conceptual model for binding structural and semantic descriptions of web services. However, they have not mentioned how to create connections between services they have developed, and there are few discussions on the sharing of e-learning resources.

Wrappers

Nakano *et al.* (2007) describe a method of creating wrappers that make web applications usable as Web services. The idea is similar to that of Grounding, by describing the semantics of web services and their operations via an ontology. Their approach begins with 'extracting important segments from an HTML document generated by the web application', then 'generating extraction rules for the wrappers'. They note that 'This extraction is performed by using the characteristic depth of each tag in the HTML document' (Nakano *et al*., 2007). They have also included an example on how to create hotel search services via this approach. Again, they have not mentioned if this approach can be applied to develop e-learning services, and how.

To conclude, no single method supports support both the descriptions and connections of e-learning resources, most of them have not been widely implemented, and there is no evidence to support how effective they are. The approaches we have identified so far are not we are looking for to develop e-learning services, in particular to share educational resources. The OECD (2007) has also mentioned about this ‘unexplored gap’, and suggested further research should be performed in this area.

2.4.3 Developments on e-learning services

As well as the rare developments on indentifying services in education, there is also not much ongoing work on support for sharing of ER via e-learning services. Many people from both industry as well as research communities have attempted to apply service technologies in e-learning (Zhou *et al*., 2009). Vossen and Westerkamp (2003) might be the earliest to propose the idea of developing e-learning services, however, in common with others, they have the following limitations.

- *Current research is not comprehensive as some of them have only addressed one type of e-learning resource.*

For example, Simone *et al.* (2005) have proposed a framework to share learning objects using service technologies, and Lucia *et al.* (2008) have developed a model to share learning content together with systems to run those contents, similar to the work of Li *et al.* (2009). However, their work has not covered the sharing of students’ records, or other applications to support assessment tasks. Li *et al*. (2009) have proposed the concept of learning services, in particular learning material delivery services, in order to allow the reuse and sharing of existing learning objects and other learning resources between different learners and on different platforms. However, they have not mentioned other types of e-learning services, such as learning monitoring or submission services.

- *Some current research about e-learning services is not comprehensive also because some of them have only focused on one service principle, in particular interoperability.*

Phankokkruad and Woraratpanya (2009) have proposed an architecture to allow e-learning services to better communicate. Sun and Fu (2005) have also investigated interoperability issues, but have not mentioned other principles such as discoverability or reusability. The Campus is a current project that makes use of the SOA concept to support online teaching and learning. This project is part of the Digital University program promoted in Spain, and eight Catalan universities have involved in the development. Campus makes use of existing e-learning applications, and restructures these applications as services. Additionally, Campus aims to improve interoperability between existing applications (Campus, 2012). There is little evidence, however, to show this architecture has the potential to improve discoverability.

- *Although there are proposals for systems, there is little discussion on implementation and evaluation of those systems.*

Ren *et al.* (2010) have developed a high level platform to share generic educational resources, by following web service standards, but their approach has not yet covered the sharing of e-learning materials, and this has not been evaluated yet. Similar to Xu and Xia's work (2010), they have proposed a platform to share e-learning resources, but their work lacks feedback from potential users. Chang *et al.* (2008) have developed and implemented a learning content providing service which is able to rank the search results for different users, but their work also has not covered sharing of other searching services, and it lacks feedback from potential users.

To summarize, there is little discussion of sharing e-learning resources using service technologies. Little work has been done to address the problems of providing descriptions as well as linking different types of e-learning resources together, and current literature lacks discussion of feedback on the implementations of these services people have developed.

2.4.4 Discussion

Increasing numbers of researchers have become interested in using service technologies to share e-learning resources. We classified them in the followings two categories.

Technical based

Most works focus on technical achievements and are interested in proposing models by using different service technologies to support different aspects of sharing. One type of model combines service technologies with other popular technologies to support the sharing of resources. For example, Andreev and Troyanova (2006) have proposed an architecture to enable sharing by considering both services and multi-agent technologies. Similarly, Wang *et al.* (2011) have proposed an architecture to enable sharing by considering both services and cloud technologies. One type of model only addresses one aspect of sharing. Banlue *et al.* (2010), have proposed a specification to describe e-learning resources semantically via metadata and an ontology, similarly Huang *et al.* (2008), Li *et al.* (2008) and Bouzeghoub and Elbyed (2006). Another example is Dicheva and Dichev's work (2010) on proposing an approach to support the searching of e-learning resources.

Educational based

There are fewer works which discuss the educational values of sharing e-learning resources. For example, in a JISC's institution development report, Rothery (2008) has introduced the strategy of sharing e-learning resources, and predicted a number of benefits, such as 'saving time and cost by reuse', 'supporting collaborative courses', and 'developing professional reputations'. However, there is no direct evidence to support his strategy from users, and there is no technical solution to support such a strategy. Another example is Kramer's work (2010), in which he has proposed a number of sharing benefits that a service approach can bring, but again, there is no technical component presented.

Our research aims to contribute to the area of sharing e-learning resources educationally and technically. From the educational point of view, our work focuses more on the applications aspects of sharing, in particular, people's sharing requirements at all stages of learning, and how users or potential users will benefit from this idea. Technically, our work also proposes a novel model to enable sharing by following the service principles, and we will collect direct evidence to support this idea in later chapters.

2.5 Summary

To summarise, we have briefly reviewed the terminologies and developments of educational resources, the state of the art in service technologies, and have evaluated how current resources are shared. A number of limitations have indentified in this literature survey.

- Limitations remain on the description of current educational resources: not all information is available to describe each resource, and some information is not meaningful. Hence, it is difficult for most users to discover, understand and choose resources.
- There is not enough management of resources: educational resources have not been well organised. There is lack of any mechanism to map existing resources to different users' needs.
- E-learning resources are not interoperable, as they rely on different implementation technologies. There is currently no 'mature' technical component to support the description, searching and sharing of e-learning resources.

- Relevant e-learning data shared among educational applications are difficult to be exchanged and reused. The first problem is that data are not available over the network to be exchanged. Secondly, there is lack of technologies to transfer data between applications. Thirdly, there is lack of technical components to process sharable data further, such as format conversion.

Hence, research question 1 – What problems do we have in sharing current educational resources – is answered. Our work is also motivated by addressing the limitations we have identified. We apply service technologies to share e-resources because it is one of the most popular and mature technologies to support resource discovery, reusability and interoperability (Yang *et al.*, 2006; Ghamri-Doudane and Agoulmine, 2007). Our further research activities and achievements will be presented in detail in the following chapters, which are guided by research questions 2 to 5 (see Table 1.1).

Chapter 3

E-learning Resources to Share

This chapter covers research we have conducted to develop educational components of our service solution: educational services and their relationships. Research question 2 is considered:

What educational resources should be shared and how to identify them?

In this chapter, we will first present the novel approach we have proposed to develop e-learning services, together with our findings, the novel educational services model, to support the sharing of current e-resources, and then evaluate current technologies that can be wrapped as services and standards to represent the e-learning data.

3.1 Introduction

The following sub questions guide our study.

SQ1: What are the main distinct processes which support a university's learning and teaching activities?

SQ2: What types of data and data flows are involved in terms of delivering a university's learning and teaching activities?

SQ3: How to abstract e-learning services from indentified processes and data flows model?

SQ4: What current applications can be wrapped as e-learning services?

SQ5: What standards are available to support the exchange of e-learning data?

The philosophy behind our work is mapping current learning and teaching requirements to available educational applications and data, by following the concept of e-services. Another outstanding feature of our approach is addressing the idea of *data flows* between e-learning applications, in order to allow e-resources to be connected. We adopt a three phase approach to identifying e-learning resources that needed to be shared. The first phase is to identify distinct learning and teaching processes from a case study, using staff interviews and literature reviews to collect data. The second stage is to identify data flows within and between these processes using a qualitative analysis. The final phase is to abstract e-learning services based on those processes and data flows. The following three sections will present the method we have applied at each phase, together with our findings and discussions.

3.2 Phase 1: Developing processes

3.2.1 Methodology

This study aims to gain a deeper understating of how learning and teaching are delivered in a university. As we have discussed in Chapter 2, we are not aware of any work that discusses how current learning and teaching processes are related and what data are exchanged between them, although the structures of universities are well understood and there is a substantial body of literature on the individual processes which underpin such institutions. The processes are identified from two sources. One is staff interviews and the other is a literature review. Staff interviews provide data to support a case study from a single university, which is used to generate our process model, and the literature review is conducted to strengthen our model by ensuring it is grounded in established administrative and educational practice. In this phase, we have applied the following sub question to guide our study.

SQ1: What are the main distinct processes which support a university's learning and teaching activities?

3.2.2 Data analysis

We have used the Department of Computer Science in the University of Warwick as a case study. Nine staff have contributed to this activity through semi-structured interviews, and due to the nature of the information we were seeking, we adopted a hybrid analysis procedure informed by approaches for identifying and combining patterns rather than making judgments about hypotheses (Hycner, 1985). This procedure consists of seven stages.

Stage 1: Generating *general themes*. By reviewing the interview transcriptions, we identified the main themes that were common to most of the interviews. The themes are represented as key phases that describe aspects of a university's learning and teaching processes, some of the typical themes are delivering modules, student assessment, module evaluation, and so on.

Stage 2: *Classifying* the interview data according to these themes. We went back to the interview transcriptions again, and examined the data that were relevant to each key phrase we identified above. For example, for 'module evaluation', all of the interviewees discussed this activity, but each addressed different aspects of it, including reviewing learning performance, collecting feedback, updating modules, and so on.

Stage 3: *Interpreting* the quotations to identify patterns. At this stage, we analyzed the interview data to identify the main learning and teaching processes and data involved. We examined the meanings of each quotation, to determine if one or more common learning and teaching related tasks are involved in each theme. We also identified the data required *before* each task, and data generated *after* each task. For example, for 'student assessment', we identified the tasks of 'delivering exams', 'delivering tests', and 'delivering assignments'; to perform these tasks, assessment materials are required, and at the end of these tasks, students' pieces of work are generated. After we developed a full list of learning and teaching tasks from the quotations, we grouped together similar tasks as a single process. For instance, we developed the process of 'delivering assessment tasks' from the theme 'student assessment' which we have mentioned above. Finally, the eight general themes we identified form stage 1 are grouped as processes.

Stage 4: *Describing* findings. We used the interview data to help us arrive at a form of words for accurately describing each process and the data it requires or generates, and also to provide a short document which discusses and identifies the issues related to each process.

Stage 5: *Combining* the findings. This stage aims to study the relationships between these processes, in order to generate a whole picture of the process model. We went back to the transcriptions again to identify evidence that describes the *order* and *relationships* between different activities, such as '…*is a start point…*', '…*is followed by* …' '…*is needed to be done before…*'. We then ordered these processes and illustrated them using a diagram to represent the process model.

Stage 6: *Validating* the findings above. At this stage, we compared the findings against the interview transcriptions to check if we have misinterpreted any quotation, or have missed out any important quotation.

Stage 7: *Strengthening* our findings by a literature survey. The staff interviews can only provide direct evidence of each process in a case study. We also need further evidence to support our proposed process model. We therefore conducted a literature survey to gain more understanding about the processes we identified, and these helped us to refine the definitions of individual processes, and to identify their relative importance. For example, Littlejohn and Pegler (2007) have classified the differences between academic and non-academic support, and Inglis (1999) and Forsyth (1995) have explored the necessity for evaluating modules whilst they are being taught.

3.2.3 Findings

The diagram below shows the learning and teaching processes (see Figure 3.1). The rectangles represent the processes, and the arrows indicate flows between these processes. A course delivery cycle is included. Teaching and learning activities normally start with the *module designing* process, followed by the process of *module planning* and *develop learning related materials*, before the actual *delivery* takes place.

When the module is delivered, it will be *evaluated* in order to identify possible future changes required to improve the module. Suggested updates suggestions obtained from the *evaluation* process will be used to guide the *module planning* and *learning material developing* processes that will take place in the next module delivery cycle.

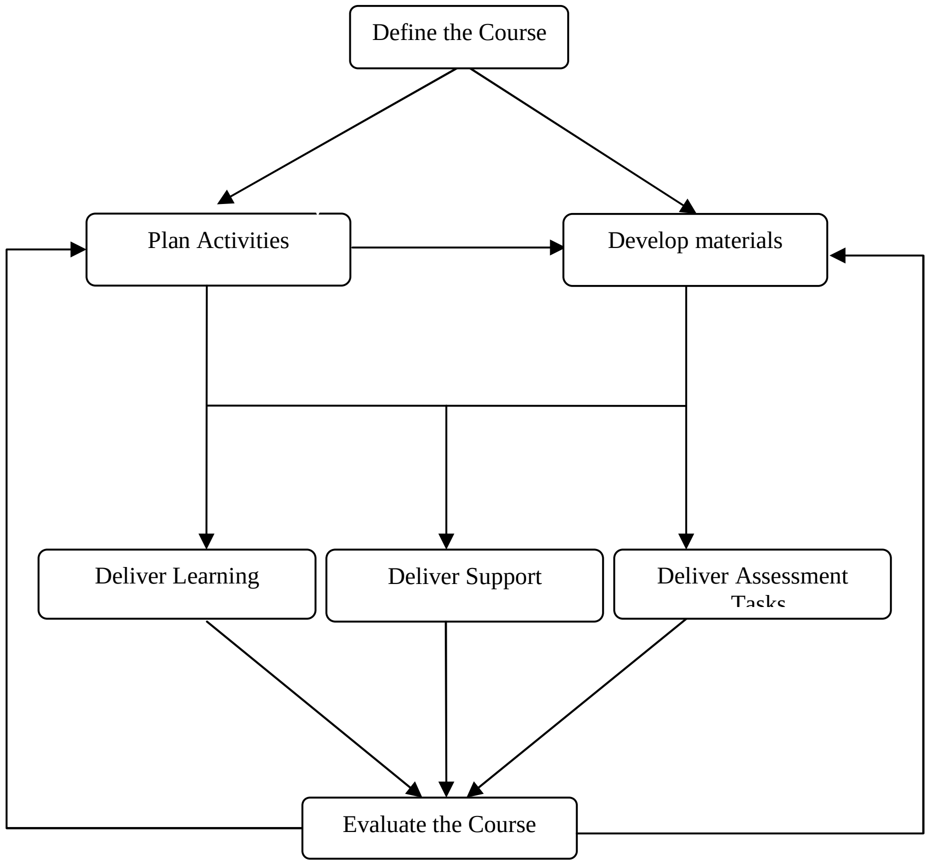


Figure 3.1: Learning and teaching processes

The following describes detailed teaching and learning processes that we will consider in our services framework.

Process 1: Define the course

Description: Designing a module normally only happens once, but the process of validating and updating a module occurs thought out the module designing process, and it probably needs to be repeated every year while delivering a module. This process usually happen once, it ends up with a formal module specification which has been validated by a number of university bodies. The specification is proposed by people (module leaders in most cases) from a department. It defines the aims, pre-requisites, learning outcomes and content (main topics) of the module (Teaching Quality). A new module is developed base on some module ideas. This might come from different rescores, such as curriculum, research results or teachers and students. The idea will be developed via a proposal module form by the module designer, where the first version of course specification, resources and learning activities are described. This formal document will then be proved by a number of internal and external bodies, including the director of undergraduate studies in the department, undergraduate steering committee, staff meeting and the university sub-faculty. These bodies will make decisions on if this new module is agreed to be delivered in the future or not, based on some criteria and their experiences. This formal module specification is then ready to be used to deliver a module. An existing module can be updated based on the experience from pervious years. If the improvement suggestions are available from process 7, it might be updated by the module organiser at any time.

Discussions: Two interviewees have mentioned that designing a module is a start point. They pointed out there are formal procedures for setting up a new module, this is a long process, and usually lasts a year to complete. Once they have an idea about a new module, they need to fill in a formal document to describe the module in terms of the aim, pre-requisites and learning objectives. This is not a paper exercise, '…*people will look at it and comment on it…* '. The document is then proved by a number of university administration bodies including Staff meetings and Sub-Faculty of Science, before it has been formally defined.

Process 2: Plan activities

Description: Module designers plan and order learning, assessing and supporting activities based on the module specification which is generated from process 1. Forsyth (1999) has mentioned that, after you have known what to teach, *planning* is the first stage for teaching a course, before the considerations of *delivering* and *evaluation*. These activities between modules are different according to the learning contents (from module specification), available teaching time, and both learners and teachers (Butcher, 2006). The typical activities are lectures, seminars, lab sessions, tests, examinations, assignments and drop in sessions (McDowell, 1991). Existing activities may be updated and/or changed every academic year if it is necessary. A module teaching plan is developed to guide the lecturer to deliver a module. It describes the main topics that are going to be covered, with the timetable to deliver it. Based on this, a number of varied learning activities, learning assessing activities and support activities are delivered depends on the module itself.

Discussions: A module organiser mentioned that once the module has been defined, it is reasonable to continue with designing and scheduling learning /teaching related activities. Usually, those learning/teaching related activities are delivered repeat every year. They are varied between modules, *'…I don't think you can generalize them…'*, and for each module, the learning/ teaching plan might vary in different years, for example, one interviewee stated that *'I don't have any seminar or lab session at the moment, when I have done it previously, they were all being used to support coursework.'*

Planning learning/teaching related activities can be done in varied ways. In practice, one interviewee's approach is to develop a teaching plan to map the module topics with available teaching slots. He stated that *'If you receive a module specification, and you also know the number of lectures and seminars per week, you have 30 lectures slots for a module…so what I tend to do, start with the main topics (from the specification of the* *module) needed to be covered, and then map these to the number of 1 to 30 depending on how many lectures I have available, so if I know I got 3 lectures for a topic, 3 times 50 minutes, so I can spend first quarter of the lecture just to introduce the topic, so I can talk about the next main thing and so on and so forth…'* In theory, John Biggs has proposed – Constructive Alignment (Biggs, 2007), the idea of which is that the components in the learning and teaching environment – the intended learning outcomes, the learning and teaching activities used, and assessment tasks – are aligned to each other. In other words, once people have identified the intended learning outcomes from a module specification, they should design what are the best learning/teaching activities which are likely to help students to achieve the outcomes, and suitable assessment tasks should be chosen to tell people if the outcomes have been achieved or not.

Process 3: Develop materials

Description: Learning, assessing and supporting materials are developed to support varied types of learning activities and assessment tasks (Clarke, 2001). During this process, assessment grading criteria are also developed. The typical learning materials are lecture slides, text books, module websites and exercises. The typical assessing materials include questions for exams, assignments and lab session questions. Some materials are created by the lectures, for example the lecture slides and module websites (Littlejohn and Pegler, 2007). People also share and reuse existing learning related sources for some modules, such as the textbooks and exam questions (Forsyth, 1999). These materials are going to be changed and updated at any time when it is necessary. Hazemi and Hailes (2002) have pointed out the production of learning materials is one of the traditional activities in a university.

Discussions: A lecturer mentioned he developed learning materials by himself. There are tools such as Latex and Site builder to support them. Also, formal guidelines are available online to guide them develop assessment materials, for example, *'… In exams, we have formats for the exam paper, which is supposed to follow…'; '…For marking,* *there are marking guidelines…we have formal procedures for first marking, and second marking…'*

In fact, not all of the learning materials are developed from scratch by the module teachers. Some of them are shared between different modules, and most of the learning materials are reused by many staff. Instead of the traditional method to develop learning materials, more and more computer based learning materials are available nowadays (Taylor, 2007).

Process 4: Deliver learning activities

Description: Learning/teaching activities in the literature often refer to lectures and tutorials, and learning materials are used to support these activities (Inglis, 1999). For example, Forsyth has written a series of books to guide educators how to deliver a module (Forsyth, 1999). However, there are many learning activities taking place outside the classroom. The changes in Higher Education and developments in educational technology enable rich sources of learning activities, such as collaborating learning (Stahl, 2006) and mobile learning (Kukulska-Hulme and Traxler, 2005). Modules are delivered differently according to the module specifications, resources and people. This process is repeated every year, and it might be updated at any time.

Discussions: For delivering a lecture, lecturers go through slides with students in a lecture room. Students might ask questions during and after the lecture. For seminars and lab sessions, students go through exercises, problem sheets, or assignments with tutors; they discuss and solve problems together with each others, ask questions and receive feedbacks from tutors. Materials may be made available to students before sessions, in order for them to prepare – '*…so students know exactly what is coming…*' Interviewees have stated that the learning activities for a module might change every year... These activities take place in the different locations: seminars are hold in classrooms, the lab sessions are run in the labs.

Process 5: Deliver assessment tasks

Description: Assessing materials are used to support varied assessment tasks which are delivered differently (Schwartz and Webb, 2002). For examinations and tests, students are required to answer a number of questions at a particular time in a particular place, and a number of lecturers and/or teaching assistants are involved with monitoring this process (Fry, 2007). For assignments, students are required to complete varied types of courseworks, including presentations, exercises, essays or reports, programming tasks, and projects. These items of coursework can be done either as an individual or as a group (Harlen, 2007). Students' pieces of work are required to be submitted in different formats depending on the type of assignment (HEA, 2005). These works are then marked based on grading criteria by lecturers and/or teaching assistants (Postlethwaite, 2004). Some coursework is required to go through the plagiarism detection task (Carroll, 2007). Marks, feedback for their assignments, and plagiarism detection results are generated at the end of this process (Parshall, 2002). Hazemi and Hailes (2002) have stated that 'that is an obvious need to assess the aptitude and progress of students'.

Discussions: Interviewees mentioned that they have different types of coursework in their modules, such as '*group presentations, individual essay and programming*'. Most of the markings are done by humans. They use grading criteria to guide the markings, *'I have a form looks like that: there are 10 marks for the design strategy, 10 marks for the quality of implementation, 10 marks* for the *quality of report…'*. Marks are recorded as electronic format such as the Excel spreadsheets. They also suggested it is good practice to provide feedbacks to students for their exams, courseworks and seminars. Currently, it is common to have individual feedback for assignments, but there is no feedback for exams, *'…that might be changing…'* One lecturer has suggested that *' instead of providing individual feedback, you provide a list of general points – lots of people got this wrong, to get this right, you got to do A, B, and C…'*

Process 6: Deliver support

Description: This process aims to provide optional support to students (Catherall, 2005). Simpson (2003) stated that most universities already have established infrastructure for student support, because they recognize that 'effective support plays an important role in retaining students and enabling them to complete their studies' (Simpson, 2002). Littlejohn and Pegler (2007) suggest that both academic and non-academic support should be covered. Examples of academic support include individual tutorial support (to give advice on learning content and feedback on learning performance), resources support (to provide library services) and technical support (to assist with technical lab work or computing) (Inglis, 1999). There is also non-academic support, such as providing financial advice (for research grants and student loads), careers advice (such as information for further degrees or jobs), and welfare support (such as accommodation services and security services) (Littlejohn and Pegler, 2007). Supporting materials are used to deliver this (Fox, 1998). Compared with the core learning activities in process 4 and assessment tasks in process 5, so far, there is no formal procedure regarding this process. Our literature review has suggested that there are fewer developments in technologies to support this process, compared with other processes such as *developing learning materials* and *delivering learning activities*.

Discussions: Interviewees have pointed out that, nowadays, students expect more support than before. No only the first year students, but also the second and final year students. For the first year students, because the high school education system has changed recently, they receive more support in school then before, and now they expect more formal support (such as seminars) and feedback than previous years' students. For the other years' students, they expect more support to help them monitor their learning, for example a support tool to manage their projects. Academic staff have also mentioned that *'the way to support them, will make teaching more complicated…'* because *'you do have to know more about teaching as well as the subject.'*

Process 7: Evaluate the course

Description: Each module requires to be evaluated in order to be improved for the next time it is needed. This process is not formally performed in practice at Warwick. Inglis (1999) notes that evaluation is required to be conducted to reflect upon the learning process and learning outcomes, in order 'to determine appropriate activities and materials that may be necessary and to inform decisions on similar activities in the future'. He also suggested using explicit criteria while designing evaluation instruments. Forsyth (1995) has also pointed out that existing learning activities and learning performance are required to be evaluated. Our interviews also suggest that evaluating learning materials is also necessary. Again, there is no formal procedure regarding this process. Each module is monitored throughout all learning and teaching activities. It will be evaluated before, during and after the delivery process (McDowell, 1991).

Discussions: Interviewees have pointed out that '*things are changing…the subjects just move on…there are new things all the time… you have to update them appropriately.'* They believe it is important to *'keep your module current'* and make sure this '*can be fixed into the module you are going to deliver next year.*' Learning contents include lecture slides, programming languages, software tools and textbooks, which might be updated when it is necessary. Interviewees mention that module evaluation is an informal process, and *'it doesn't happen very much.'* Teachers first evaluate students' learning performance and review students' feedback. According to their evaluation results, they then update their modules correspondingly in order to keep them current.

Teachers review students' learning performance by '*analysing the marks to identify problems'*. A lecturer pointed out that he used to check if the marks are reasonable for each topic, *'if everybody who tried a topic in the coursework failed, something went wrong, on the other hand, if everybody try another topic, and get 100% right, again, something went wrong...'* and he will figure out the solution by doing something else later. Students' feedbacks about learning are collected by having more questionnaires or student feedbacks and assessment forms at the end of each module (Catherall, 2005).

We suggest that a module can be evaluated against the following 3 questions, and the possible results are also included.

- Has the module been planed well? Feedback from learning activities analysis before and after the process of module delivery (which is also the beginning of next year's module), to guide the changes on module design.
- Has the module been delivered well? Feedback from learning materials analysis during the process of module delivery, to guide the changes on learning materials while the module is being delivered.
- Have the students learnt well? Feedback from learning performance analysis after module delivery, to guide the updates of learning activities and learning materials for the following years.

3.2.4 Discussion

This study has indentified 7 distinct processes which support a university's learning and teaching activities, hence, the first sub question is answered. In order to obtain *real* and *qualitative* data, a realistic case-study at a single institution will provide sufficient data (Coleman and Briggs, 2002). We have interviewed a variety of academic staff involved in all aspects of the delivery of undergraduate and masters' courses in the Department of Computer Science. The choice of a computing department is appropriate since its internal processes are likely to make good use of an IT infrastructure. Of course, it is understood that processes will vary between institutions and between individual departments, in particular between social science and natural science subject areas, but an exploration of those differences is beyond the scope of our research.

3.3 Phase 2: Developing data flows

3.3.1 Methodology

According to the findings from interviews, data and data flows are identified by reviewing the learning and teaching processes. In this stage, we describe and discuss the data and data flows we have found. We first list all the data which are involved in each process, in terms of inputs, outputs and available options for some particular data types. We then present and classify all the available data, and finally combine the data flows into our existing processes. The following sub question has guided us.

SQ2: What types of data and data flows are involved in terms of delivering a university's learning and teaching activities?

3.3.2 Data analysis

According to the findings from interviews, data and data flows are identified by reviewing the learning and teaching processes. We conducted a qualitative data analysis, suggested by Watling (Cohen *et al.*, 2005) for research in educational management, as follows.

Stage 1: Identify *data* from process flows. We went back to the processes developed already, and identified types of data, which included module specifications, teaching plans, learning materials, assessment material, marks and feedback.

Stage 2: Identify *linkages* between data. Based on the process descriptions, we then highlighted all the linking words to represent the data flows, such as '…*based on*…', '…*end's up with*…', '*after*…' and so on.

Stage 3: *Combine* data flows and the process flow diagram. Based on the data and data flows we have identified from stages 1 and 2, we then studied what and how the data are shared between different processes, and for each data item, how it was developed and what data are generated based on it.

Stage 4: *Simplify* the process and data flow diagram. At this stage, we reviewed our diagram again, to study if there are any similarities between data flows, and to identify any data flow cycles in the diagram. For instance, the data flows for delivering learning materials, assessment materials and supporting materials are similar to each other.

Stage 5: *Validate* the findings against the process flow diagram. We compared our results with the processes to check if we have missed out any important flows or misinterpreted any of them.

3.3.3 Findings

The second sub question is answered. This diagram (Figure 3.2) shows the learning and teaching processes and their data flows, developed from the first two phases of our approach described in sections 3.2 and 3.3 so far. The rectangles represent the processes, and the arrows and (unboxed) text indicate data flows between these processes.

In order to help us to clarify this model, we will introduce a sample below to show how a typical undergraduate JAVA programming module is delivered at a UK university in practice. The up to date information about this module can be accessed at the module website (http://www2.warwick.ac.uk/fac/sci/dcs/teaching/modules/cs118/).

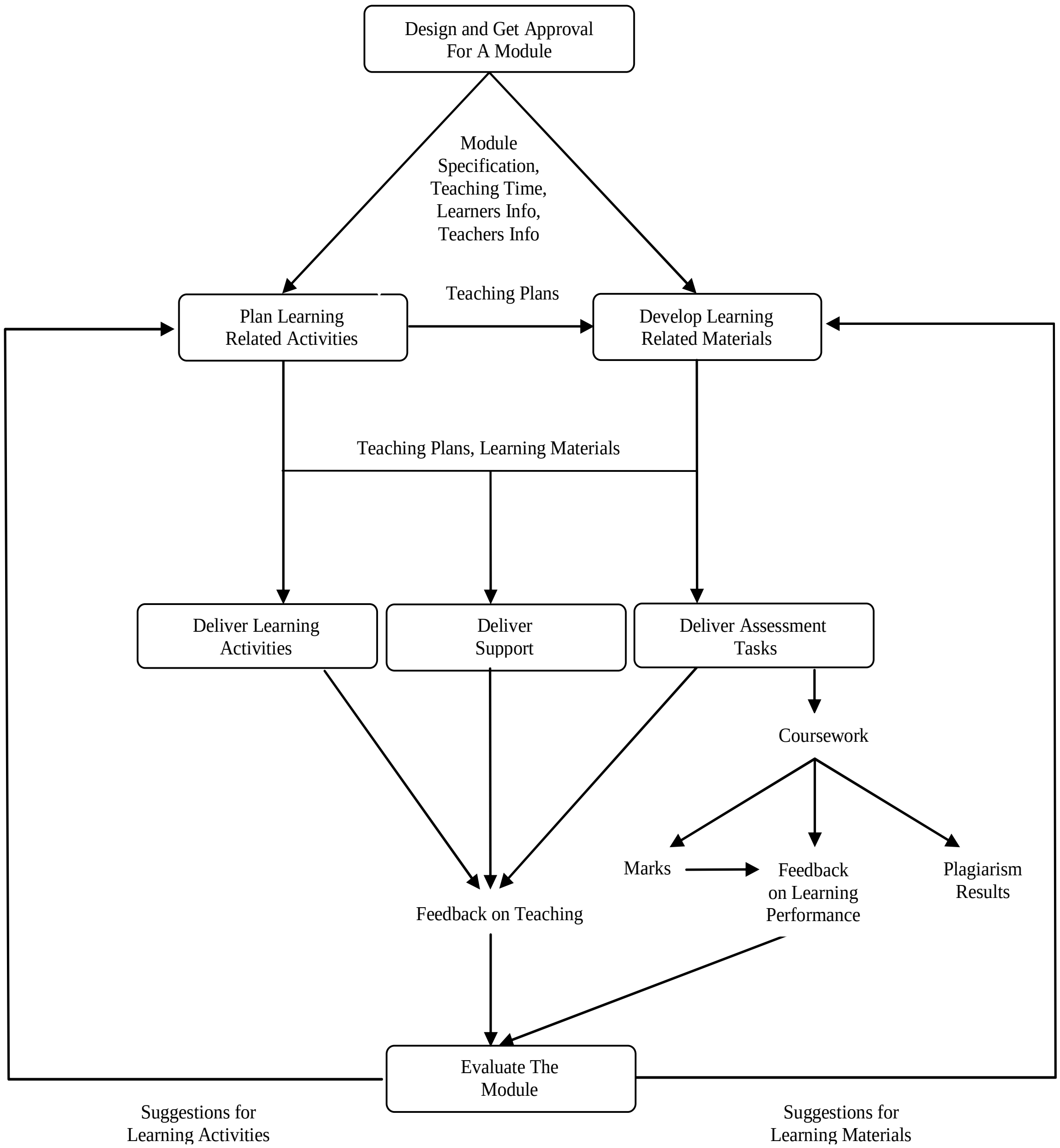


Figure 3.2: Processes and data flows model

At the end of the process '*design and get approval for a module*', the module specification is validated, data such as the learning outcomes, hours of lectures, hours of seminars, number of tutors and lecturers are required, level of students and their pre-requisites to take this module are defined. Typical data generated in this module are:

<u>Module specification</u>
Pre-requisites
    None
Level of students
    First year undergraduate
Learning contents
    Understanding of data types
    Understanding of objects and classes
    Understanding of program control structures
Learning outcomes
    Building Elements: Pre-conditions and post-conditions; Basic data types; Variables, identifiers and scope.
    Programming with objects and classes: Complex data types; Parameter passing by reference and by value; Encapsulation.
    Control structures: Conditionals; Case statements and loops; Correctness issues when programming with loops.

<u>Teaching time</u>
20 lectures and 10 seminars, term 1

<u>Teachers' information</u>
Lecturer: Stephen, Room 118
Guest lecturers: John; Mike; Jenny
Tutors: Jane, Room 111; Jacky, Room 112; Nick, Room 113

<u>Learners' information</u>
A list of student names and their ID, contact information, marks on each coursework etc.

Based on the information generated from the pervious process, module organiser then begins to *plan learning activities, supporting activities, and assessment tasks* etc. By the end of this process, detailed teaching plan for this module is developed. Timetables for different types of activities, people are involved for each activity, learning related materials required for each activity are described:

Teaching plan

Overview

This module covers many of the features and techniques needed for computer programming. The first half of the module is structured so that the necessary components of procedural programming are introduced. The second half of the module develops on the earlier techniques but with particular application to object oriented programming.

Plan for learning activities

Lecture timetable, lecturers; seminar timetable, seminar groups, seminar tutors

Plan for supporting activities

Drop-in sessions: time, location, helpers' information

Plan for assessment tasks

1 exam: one 2 hours exam in June
1 test: one hour test in December
2 courseworks with deadlines

According to all the data the module organiser has obtained so far, *learning materials, support materials and assessment materials are also developed*. As shown below:

Learning materials

Module syllabus
Lecture slides (PDF files)
Textbooks
Course wiki
Module forum

Support materials

Learning support materials
- Additional learning materials (books, web links)

Technical support materials
- Web links
- Support teams (IT service, Linux help)

Assessment materials

Formal guidelines for developing each assessment
Courseworks information, deadlines, resources (PDF files, program codes, tools)
Exam paper
Test paper
Grading criteria for each assessment

The learning plan and learning related materials are then be used to *deliver learning activities, support activities and assessment tasks*. Feedback on different types of learning activities and learning related materials are generated:

Feedback on teaching

'The link in slide 3-12 is not valid any more'
'Further readings are required to help with completing assignment 2'
'More support for installing Java on students' own machines is required'

After the process of deliver assessment tasks, not only the students' courseworks, marks, and plagiarism detection results, additional data such as feedback on students' learning performance are also generated:

Coursework
Exam answers
Test answers
Program codes for each assignment

Marks
Marks from exams
Marks from tests
Marks form courseworks

Plagiarism detection results
Detection results for each coursework submitted

Feedback on learning performance
Feedback on exam

'Students found that 'Program control structures' is difficult to understand, most of them have lost marks in the exam'

Feedback on tests marks
Feedback on coursework

After varied learning activities and learning related materials are delivered, and feedback on learning preference and delivering of teaching are generated, this module can then be evaluated. The suggestions generated during the process of *'evaluate the module'* can then be used to update the design of learning activities and materials for this module in the following years.

Suggestions for learning activities

'Add further support for installing Java on students' own machine'
'Add a tutorial to help students to better understand 'Program control structures'

Suggestions for learning materials

'Update the link in slide 3-12'
'Add tips in assignment 2'

3.4 Phase 3: Developing e-learning services

Before we present the services we have indentified, this section first describes how we have abstracted them from existing processes and the data flows model.

3.4.1 Methodology

We develop e-learning services by identifying major data flows between these processes. For each identified service, we describe its function and the motivation for using it, along with its input and output data. We have also made sure that each service meets all of the service features we have mentioned before. Although some researchers (Ha and Lee, 2006) have stressed the use of UML diagrams to represent work flows between services, we note that there is no established methodology which we could apply to abstract e-learning services from concrete processes and data flows. The following sub question has guided us.

SQ3: How to abstract e-learning services from indentified processes and data flows model?

3.4.2 Data analysis

The first step is to study existing current educational software that matches with the processes we have indentified. In this task, we have made sure there are more than one software application is available to handle each process. Secondly, we examined data that have been used and their data flows between the software, in order to link these applications together, according to the data flows in the model. For example, students' e-assignments are passed from a submission application to a marking tool. After that we went back to our model, and added data processing information to it, such as how a particular type of data is collected, where these data have been processed, and so on. This task helps us to understand how educational data are processed clearly. Then we grouped these software into services and made sure they are all consistent with our working definition and attributes of services. Finally, we checked our services against with the processes and data flows model to make sure we didn't miss any anything from it (Yang and Joy, 2009). Meanwhile, we also made sure that each identified service meets all of the following service features we identified before in section 2.3.2.

- Services are independent to each other: services are offered by multiple providers, each one is a stand alone component, which is languages independent and platform independent.
- Services are interoperable: services are connected, as data can be exchanged and reused between services.
- Services are selectable: services with similar functions are available, with detailed descriptions. Users and developers can view and easily make choices between them depending on their requirements.
- Services are reusable: each service can be reused by many users, and data can also be reused in different services for different purposes.

3.4.3 Findings

The following nine e-learning services have been identified, and a service diagram is included below (Figure 3.3). The rectangles represent the e-learning services, the arrows and unboxed text indicate data flows between these services, and the dashed lines indicate that services might be combined. Each service represents common function contains in current e-learning applicants, and their data flows show how the data are shared and exchanged between these e-learning applications. For example, based on the module specification (See section 3.3.3 for details), module organiser can discover and choose suitable learning related materials from an instance of *learning materials development service* – Jourm, and upload them to a popular *learning* *materials delivery service* – Moodle. Students then use Moodle to learn the subject and complete their assignments there as well, where Moodle can be seen as an instance of *assessment delivery service* as well. Their submissions are sent to a *marking service* – OpenMark to generate marks and feedback, their assignments are also sent to service – Turnitin to *check for plagiarism*. Details of relevant technologies to realise each e-learning service will be discussed later in section 3.5.

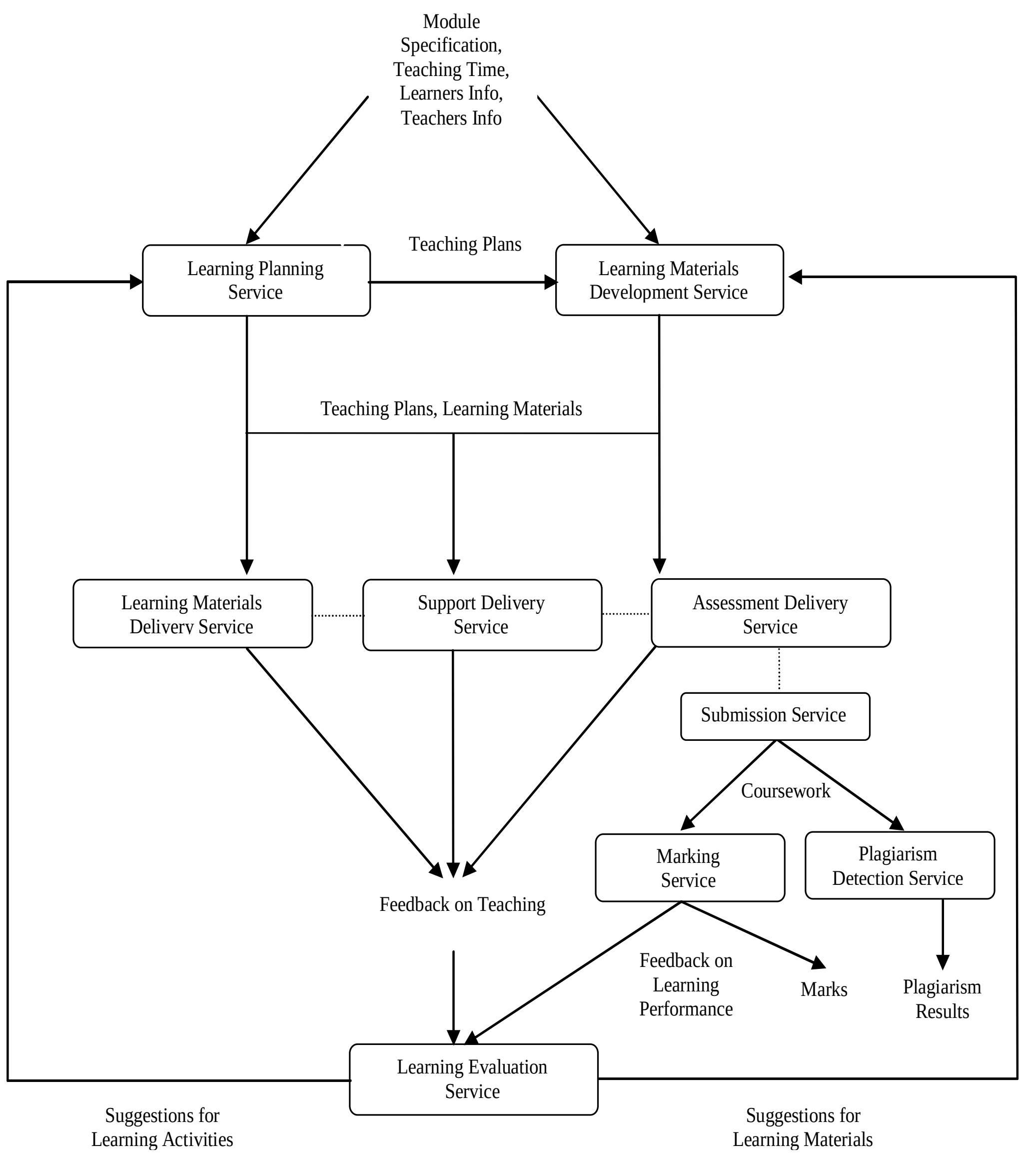


Figure 3.3: Services and data flows model

Learning planning service

Motivation: Learning and teaching activities vary between modules, planning these activities can be done in varied ways, and various planning approaches exist (Catherall, 2005). Having such a service enables educators to easily make choices between the available services offered by multiple vendors, according to their needs.

Functionality: This service aims to assist module designers to develop a module delivery plan. By using basic factual and educational details, this service will allow selection and planning for all learning, supporting and assessment activities for a particular module. A list of available services can be discovered from the e-learning services registry; however, there are few well developed products that currently support this.

Input data:

- Module specification
- Learners' information
- Teachers' information
- Teaching time
- Suggestions for learning activities

Output data:

- Learning plan

Learning materials development service

Motivation: This service first enables the sharing and reuse of learning resources, and provides an environment to support educators to develop learning materials (Clarke, 2001). Additionally, some services might enable support for specific development approaches, such as Biggs' Constructive Alignment (Biggs and Tang, 2007). A service instance might, for example, enable validation of learning materials by performing an automatic check to ensure consistency with other module components including the intended learning outcomes and learning activities.

Functionality: This service aims to handle computer based learning related materials for learning, assessment and support. It assists module designers to search and select a number of existing computer-based learning and assessment materials, and also supports the creation of new computer based materials. The developed materials can then be easily wrapped as SOAP messages, to be passed to other services, such as the learning materials delivery service, which will be covered later on.

Input data:

- Module specification
- Learners' information
- Teachers' information
- Teaching time
- Suggestions for learning materials
- Learning plan

Output data:

- Learning materials
- Support materials
- Assessment materials

Learning materials delivery service

Motivation: Many Learning Management Systems (LMS), such as Moodle (2012), have been developed and are becoming mature (Hazemi and Hailes, 2002). This service will reuse these existing products and allow teachers/learners to select between them.

Functionality: This service aims to deliver learning materials based on the pre-defined learning and teaching plan. A computer based learning environment is provided, which allows varied learning materials to be delivered, where learners can easily get access to and make use of them at any time. Existing LMSs can be wrapped as services by adding WSDL interfaces to each of them.

Input data:

- Learning plan
- Learning materials

Output data:

- Feedback on teaching

Support delivery service

Motivation: Research results from our interviews suggest that students increasingly expect high levels of support, and this is particularly true of first year students who have recently graduated from high school (Fox, 1998). This service is designed to address this issue, so users can freely make choices between varied support providers. Currently few appropriate tools are available.

Functionality: This service provides a computer based supporting environment to deliver academic support, based on learners' requirements. Learners can easily get access to and make use of support materials, and also communicate with tutors and/or peers any time and anywhere.

Input data:

- Learning plan
- Support materials

Output data:

- Feedback on teaching

Assessment delivery service

Motivation: Many Learning Management Systems can be used to deliver assessment materials (Harlen, 2007). This service will reuse these existing products and also allow teachers/learners to make selections between them from different LMS developers.

Functionality: This service aims to deliver assessment tasks based on the pre-defined learning/teaching plan. Similar to the learning materials delivering service, a computer based delivery environment is provided, which contains a number of varied assessment materials for learners. Both learners and teachers can easily get access to support materials any time and anywhere. Again, existing LMSs can be wrapped as services by adding WSDL interfaces to each of them, which can then be combined with a learning materials delivery service via BPEL.

Input data:

- Learning plan
- Assessment materials

Output data:

- Feedback on teaching

Submission service

Motivation: Many pieces of coursework are required to be handled every year. This service enables students to submit their work anytime and anywhere. Instructors can choose an appropriate submission service for each assessment task from multiple service providers.

Functionality: This service allows coursework to be submitted in an electronic format. Teachers can easily get access to students' work via this service. Such a service might take the form of a component of an LMS, or might be a specific product such as BOSS (Joy *et al.*, 2005).

Input data:

- None

Output data:

- Coursework

Marking service

Motivation: Many pieces of assessment work are required to be marked every year, and our interviews have suggested us that this is a time consuming task for markers. This service enables marks to be generated easily based on grading criteria, and both individual and overall learning performances are analysed.

Functionality: This service assists markers to handle the marking job easily. Marks and feedback on students' learning performances are generated by this service. Many e-marking systems have been developed, such as SCORIS (2011) for marking e-tests and e-exams, and could potentially be presented as services.

Input data:

- Coursework

Output data:

- Marks
- Feedback on learning performance

Plagiarism detection service

Motivation: Many pieces of coursework are required to be handled every year, and detecting plagiarism is a time consuming task for human beings (Carroll, 2007). This service enables the detection task to be done by machines. Instructors can choose appropriate plagiarism detection services for different assessment tasks from multiple service providers. Furthermore, software for detecting plagiarism already exist, including the Turnitin (2012) products for essays, and JPlag (2012) and Sherlock (2012) for computer programming assignments.

Functionality: This service assists markers to detect plagiarism easily. It compares students' assessments against each other's, and also against available web resources.

Input data:

- Coursework

Output data:

- Plagiarism results

Learning evaluation service

Motivation: Modules are required to be updated all the time. In practice, there are a few formal procedures for this task (McDowell, 1991). The learning evaluation service allows educators to easily choose to receive suggestions on improvements for delivering either learning activities or learning materials or both.

Functionality: This service aims to evaluate the delivery of learning activities, learning materials and students' learning performance. Two types of feedback are considered, one is teaching feedback, which refers to the quality of learning, support and assessment activities and materials. The other is feedback on each student's learning performance. Examples include how well an individual student has done for a particular assignment or overall semester performance. Evaluation results can be used to guide the updates of existing learning activities and materials either immediately or for future delivery.

Input data:

- Feedback on teaching
- Feedback on learning performance

Output data:

- Suggestions for learning activities
- Suggestions for learning materials

3.4.4 Discussion

The third sub question is answered. We have indentified 9 distinct e-learning services to support the sharing of current educational resources, based on a case study at University of Warwick. The results might not be general enough to apply to any department or any university all over the world, some specific processes, data or data flows in other educational organisations might have been missed out. These are e-services only. They can't handle all the learning and teaching tasks, for example the task of delivering a lecture has to be done by humans. E-services can only perform some necessary computer based tasks. They will be implemented as software components containing functionality that can contribute to some of the teaching and learning activities. Each service concept contains a number of service instances. These service instances are provided by different services providers. For example, the ASSET assessment service (2012) is provided by Reading University, where the OpenMark service (2012) is provided by Open University.

3.5 Current applications as services

SQ4: What current applications can be wrapped as e-learning services?

This section presents a number of current tools and/or systems that have potential to be wrapped as e-learning services. We will highlight what kinds of tools are available first, and then evaluating them by mapping these tools with the services we have indentified in the rest of this section.

The following lists a number of typical systems and tools that support e-learning as well as e-assessment activities currently.

Reload Colloquia

The Colloquia is a free learning management system which supports group working. It encourages self organising groups, and allows personal information to be shared within each learning group. The software provider has stated that ‘each learning group can involve users of different roles (teachers and learners), the use of learning objects, group tasks and individual assignments. As a multi-user system, it also follows specifications such as IMS Learning Design (RC, 2012).

asTTle

asTTle is an educational service for assessing students’ learning performance developed by the Ministry of Education via the University of Auckland, New Zealand. It supports teachers to create and analyse tests for literacy and numeracy for their own students' learning needs. Educators can create 40-minute tests by using this tool, via accessing large, high-quality item banks. Once the tests are scored, the tool will generate graphic reports that allow teachers to analyse student achievement against curriculum levels, curriculum objectives, and population norms. The reports will show information on the strengths and weaknesses of individuals and groups, for example, what students know, what gaps they have in their learning, and what they need to learn next. The results also indicate how well students are learning in comparison with other students nationwide. An Internet link is provided to help teachers choose resources that will help move the student learning forward (AsTTle, 2012).

Assessment21

Instead of supporting simple multiple choices which can be automatically marked, Assessment21 can handle both examinations and assignment questions with learning feedback and results analysis. It contains authoring tool to enable the development of multiple questions, an exam and assessment browser tool with a ‘cheat proof’ secure mode, as well as a marking tool. It also supports connections to other student record systems and e-learning systems APIs (Assessment21, 2012).

Moss

Moss is an Open Source application for detecting plagiarism in programming classes, by comparing the similarity of computer programs in the languages C, C++, Java, Pascal, Ada, ML, Lisp and so on (Moss, 2012).

Evaluation on current technologies

Table 3.1 below compares above e-learning products against with services we have indentified. Beside these have been mentioned above, the other e-learning applications in table 3.1 have been introduced earlier, please refer to section 2.2.2 for details.

The findings suggest that about half amount of applications can be plugged in as services directly, such as Sherlock (2012) and Turnitin (2012) for plagiarism detection, MERLOT (2012) and JORUM (2012) for learning content development, as they only support one or two simple and straightforward learning tasks. Currently, there are few tools available to support ‘support delivery service’, this gap might be addressed by further e-learning technology developers or service providers. For the rest of the applications, further modifications are required. In particular, separating current complex systems into small units of services are suggested to be conducted in the future. For instance, Moodle can be divided and reused as a learning materials development service, learning materials delivery service, assessment delivery service and marking service. Conversely, some current applications can be combined and interoperate together to support certain learning processes, for instance, searching 4 different repositories to discover e-learning contents for a given topic.

To summarise, most currently available e-learning systems and tools can be wrapped as services, they are more focused on supporting learning and assessment activities, rather than the evaluation of learning activities. Hence, SQ4 is answered. However, perhaps half of them cannot be plugged in straightforwardly, as further modifications are required. We suggest that further technical work might require to separate or recombine current applications more effectively, in order to better reuse and share them.

E-learning Products / Services	Learning planning service	Learning materials development service	Learning materials delivery service	Support delivery service	Assessment delivery service	Submission service	Marking service	Plagiarism detection service	Learning evaluation service
Reload Colloquia	✓	✓	✓	×	✓	×	×	×	×
Sakai CLE	✓	✓	✓	×	✓	✓	✓	×	×
Moodle	✓	✓	✓	×	✓	✓	✓	×	×
MERLOT	×	✓	×	×	×	×	×	×	×
ARIADNE	×	✓	×	×	×	×	×	×	×
JORUM	×	✓	×	×	×	×	×	×	×
asTTle	×	×	×	×	✓	✓	✓	×	✓
Assessment21	×	×	×	×	✓	✓	✓	✓	✓
OpenMark	×	×	×	×	×	×	✓	×	×
Boss	×	×	×	×	×	✓	✓	×	×
Moss	×	×	×	×	×	×	×	✓	×
Sherlock	×	×	×	×	×	×	×	✓	×
Turnitin	×	×	×	×	×	×	×	✓	×

Table 3.1: Mapping current e-learning products with our services

3.6 E-learning data representations

Data representation covers structuring, meaning, and particular vocabularies associated with data (Banlue *et al.*, 2010). Open data specifications play an important role in sharing e-learning data, as these support the real interoperability between systems, in particular among interfaces and protocols. Having an agreed set of data specifications provides a common language to communicate. It allows two systems to import and export data (Arch-int *et al*., 2005). Many organisations are developing standard data models support this, including IMS Global Learning Consortium (IMS GLC), The Advanced Distributed Learning (ADL), IEEE Learning Technology Standardization Committee (LTSC), and ISO JTC1/SC36 Information technology for learning, education and training. This section summarises a number of current standards and/or specifications, which can be used to describe e-learning data that we have indentified in earlier research. Again, we will evaluate these products afterwards.

SQ5: What standards are available to support the exchange of e-learning data?

It is commonly agreed that most e-learning data are stored in databases, and are described by XML files (Huhns and Singh, 2005). Nowadays, a number of data models have become available to describe different types of data, and many international organisations are working on this. For example, IMS global learning consortium has developed the most well known standard 'Content Packaging' to describe learning recourses (IMS, 2012), IEEE has the standard 'Learning Object Metadata' (LOM, 2012), as well as the SCORM from the Advanced Distributed Learning (SCORM, 2012). In the rest of this section, some of the popular standards are described.

ADL SCORM

Sharable Content Object Reference Model (SCORM) is specification for describing the 'structure' and 'behaviors' of learning contents, which is developed by ADL (see

Section 2.2.2 for more details). It contains 3 sub specifications, the first one is content packaging, which describes how learning contents are packaged and described using XML, the second one is the sequencing section, and it specifies the sequence in which a learner may experience content objects, so the learner is directed to follow a fixed set of paths through the learning materials. In the run-time section, how learning contents should be launched, and how they are communicating with other systems, are defined in the third specification, as shown in the diagram (Figure 3.4) below. Learning resources are required as the format of SCOs or assets. The difference between them is that an SCO can communicate with e-learning systems but an asset cannot. According to the specification: ‘an item element may reference to a resources element, the same resource may be referenced by more than one item element, the root of the tree is the organization element.’ (SCORM, 2012)

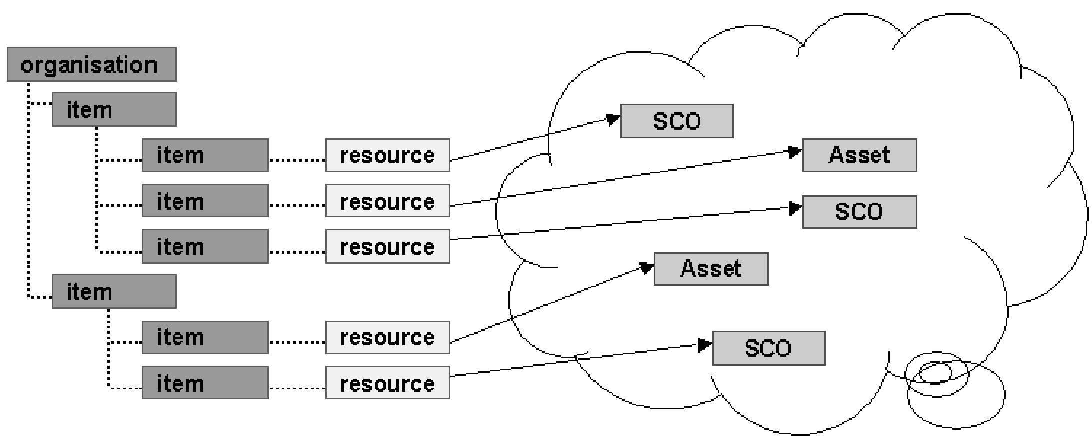


Figure 3.4: Structure of SCORM (Source form SCORM, 2012)

OKI OSID

The Open Knowledge Initiative (OKI), which is funded by the Andrew W. Mellon Foundation in the US, has developed a specification – the Open Service Interface Definitions (OSID) – to support the interoperability of ER. The OSID includes information such as repository, timetabling, workflow, messaging, assessment, authentication and identity (OKI, 2012).

IMS Content package

Content Packaging specification describes e-learning data structures that can be used to exchange between systems, in order to export contents from one learning management system or digital repository and import it into another. The most widely used content packaging format is defined by IMS Global, which uses an XML manifest file called 'imsmanifest.xml' in a zip file. The format of learning content itself is included in a zip or HTML file, or is referenced as a URL within the manifest. A content package (CP) is a file containing content and metadata and is used to define some learning contents that can be delivered, for example, by a Learning Management System. It is a standard way of describing learning content that can be read by many other e-learning applications. The contents include text, images, sounds, flash objects, software programs, and collections of HTML or PDF files and so on. Each CP contains the following three components: metadata to describe the content, organizations to structure the content and resources to get the content (IMS Global, 2012). The relationships between each of these components are shown below (figure 3.5).

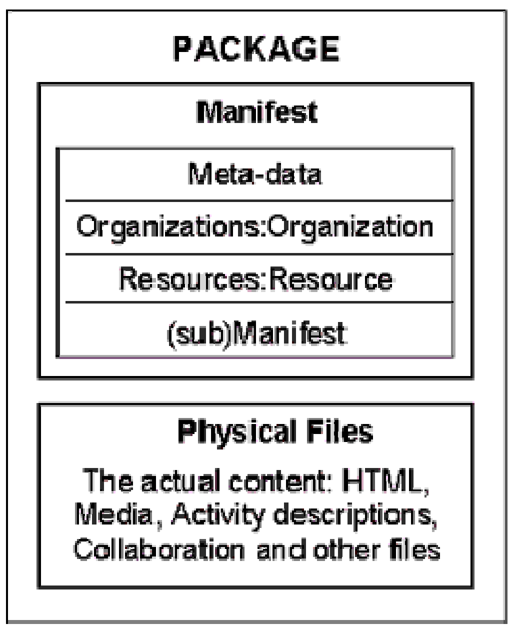


Figure 3.5: Structure of IMS Content Package (Source form IMS Global, 2012)

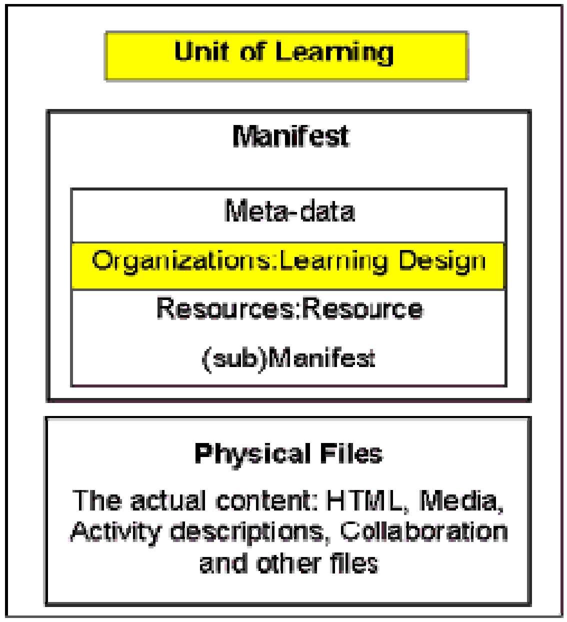


Figure3.6: Structure of IMS Learning Design (Source form IMS Global, 2012)

IMS Learning Design

IMS Learning Design is a data model to describe orders of learning activities among multiple students and teachers. It is more powerful than IMS Content Package, which is for single learners only. Learning design instances describe a set of learning activities, which learners will perform together in the context of a certain learning environment, in order to achieve certain learning objectives. As shown as the diagram (Figure 3.6) above, the Learning Design adds the following elements to the existing IMS Content Packages: 1) Learning objectives and prerequisites, 2) A set of activities such as assessment, lessons and discussions, and 3) roles that each learner or staff needs to perform (IMS Global, 2012).

IMS Learner Information Package

LIP is a data model to describe information about each learner. It contains the elements including ID, Learning goals, skills, qualifications, transcript and interests. A number of items of personal information are also considered, such as learning preferences, language capabilities, and records of courses undertaken previously with their learning performance (IMS Global, 2012).

IMS Reusable Definition of Competency or Educational Objective (RDCEO)

Learning objective elements can be defined by this specification (Figure 3.7). Identifier defines the educational objective of this learning material. Title is a single name for the objective. Description is a human readable description of the competency. Definition provides a more complete definition of the educational objective. Metadata record further information related to the RDCEO. Beside identifier and title, other components are optional, and they can all be represented in multiple languages (IMS Global, 2012).

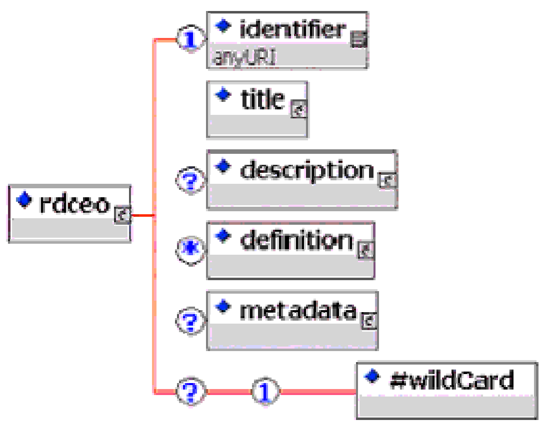
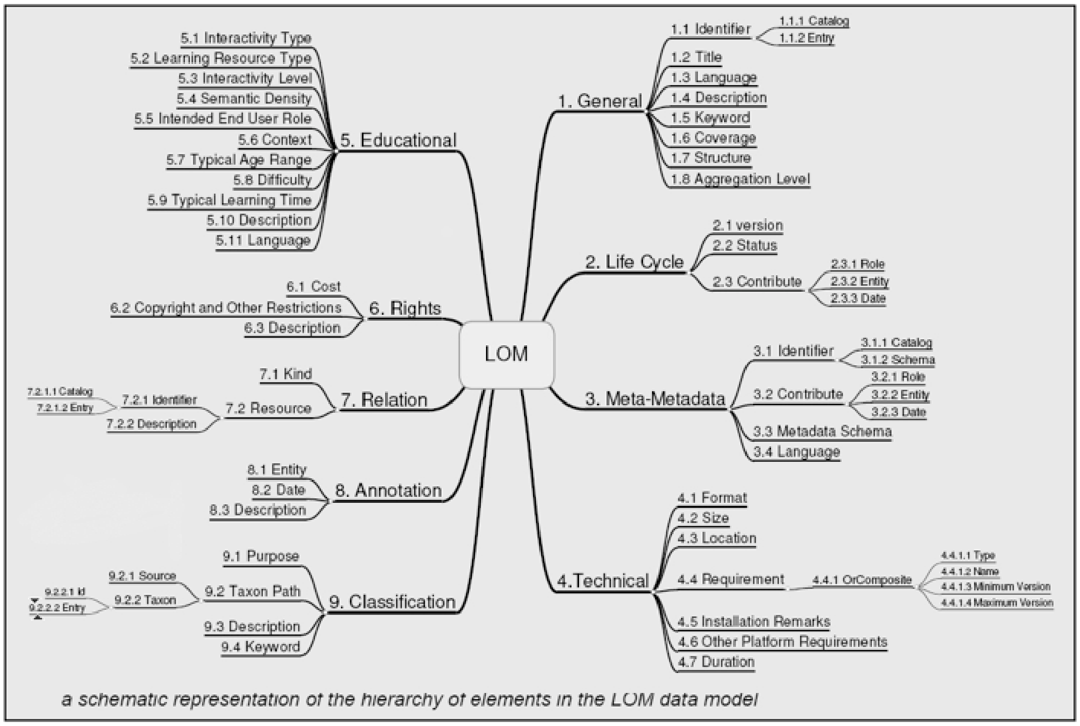


Figure 3.7: Structure of RDCEO (Source form IMS Global, 2012)

IEEE LOM

IEEE LOM is another data model (see Figure 3.8) to describe learning objects. Each package contains information about each learning object including type of object, author, owner, format, as well as pedagogical attributes, such as teaching or interaction style (LOM, 2012).



a schematic representation of the hierarchy of elements in the LOM data model

Figure 3.8: Structure of IEEE LOM (Source form LOM, 2012)

IMS Question and Test Interoperability

The IMS Question and Test Interoperability specification (QTI) defines a data model for the representation of assessment questions and test data and results, for the purpose of supporting the exchange of these contents between authoring and delivery systems, repositories, test constructional tools, learning systems and assessment delivery systems. As a result, e-assessment contents can be authored and delivered on multiple systems interchangeably. The data model defines the structure of questions, assessments and learning results with an XML data binding. The XML binding is widely used for exchanging assessments between different authoring tools and by publishers. The results parts of the specification are less widely used (IMS Global, 2012).

ADL Dublin Core

The Dublin Core set of metadata are used to describe and categorize e-learning content. It uses 15 text fields to describe e-resources like books, videos, sound, image, or text files, and composite media like web pages. Implementations of Dublin Core typically make use of XML. People also look at Dublin Core as a 'small language for making a particular class of statements about resources' (Dublin Core, 2012).

Evaluation on current technologies

The following table (Table 3.2) maps the e-learning data we might need to share with available standards and providers to support them.

Data types	Standards	Developers
Course specification	RDCEO	IMS
Learner information	LIP	IMS
Learning plan	SCORM	ADL
	OSID	OKI
	LD	IMS
Learning materials	CP	IMS
	LOM	IEEE
	Dublin Core	ISO
	SCORM	ADL
Assessment materials	QTI	IMS
Supporting materials	No available	No available
Evaluation data	LD	IMS
	QTI	IMS

Table 3.2: Standards to represent e-learning data

Sub question 5 is answered. Currently, most specifications focus on the descriptions on e-learning and e-assessment materials only, and other data types, such as course specification, learning plan, learner information, and evaluation data have not been addressed widely. There is no data model which describes materials to support learning experiences.

3.7 Summary

Limitations

The data we have collected for this research is strong on reality and up to date. All the interviewees are academic staff with teaching experience in the Department of Computer Science at the University of Warwick. This research has provided a deeper insight of how a module is delivered in this institution. As a case study, the results might not be general enough to apply to all other departments or institutions, as some specific processes and data in other subject areas might have been missed out, and also the sample size for this research is not big enough to support quantitative data analysis. We have only covered limited technical implementations in this thesis.

Validation

Delivering of the staff interviews allows us to indentify the main distinct learning and teaching processes in a single university, and to describe each process with relevant evidence. Our approach is developed by following the standard approaches introduced in Cohen's book 'Research Methods in Education' (Cohen, 2005), for analysing our interview data.

This chapter was guided by considering the followings:

- What educational tools should be shared?
- What educational data should be shared?
- How are the identified educational tools and data interrelated?

We have proposed a novel approach to developing e-learning services from complex learning and teaching activities, to support the sharing of e-resources. We have also identified and presented nine distinct e-learning services and their data flows that can be easily reused and shared by learners and instructors. These services are fundamental educational components to support our educational services framework. We have also conducted a literature survey to evaluate current developments on applications and data standards to enable the sharing e-resources. Hence, research question 2 – What educational resources should be shared and how to identify them? – is answered.

Our earlier literature review has also indicated that our proposed approach and services model did not previously exist (see Section 2.4.2). Although some scholars have discussed one or more individual processes in their works, none of them has comprehensively studied and linked all the distinct processes together as a whole (see Section 2.1).

The survey we have conducted in sections 3.5 suggests that more attention is required to be paid on the processes of *learning support* and *evaluation*. Currently, technologies to support the *development of learning materials* and *delivering of learning activities* have been developed widely and have become mature. However, few technical developments are taking place relating to *learning planning*, *course evaluation* and *learning support*, in particular, the concepts of *learning and teaching feedback* and *learning support* have been discussed extensively in the education domain (Fox, 1998; Stahl, 2006).

The evaluation of e-learning data standards we have conducted in sections 3.6 suggests that there are few ongoing technical developments which address describing course specifications, learner information, evaluation data and supporting materials.

Our identified services might be implemented by mobile devices, for example the e-learning and e-assessment delivery services will enable the delivery of mobile learning (Su *et al*., 2007). In practices, not all of the services need to be used, it only depends on the user's requirements. The services are discoverable, reusable at run time, and are managed by other technical components in our framework. Details about the technical components to share these services will be addressed in the next chapter.

Chapter 4

Educational Services Architecture to Share Resources

This chapter covers research we have conducted to develop technical components of our service solution: Educational Services Architecture. Research question 3 is considered:

How can identified educational resources be shared?

This chapter will start with presenting our proposed architecture, followed by a discussion of the state of the art on the implementation technologies that develop the e-learning services and components of our architecture.

4.1 Introduction

In order to guide us to develop the architecture, we have divided question 3 into the following sub questions:

How can identified educational tools and data be described?
How can identified educational tools and data be structured?
How can identified educational tools and data be connected?

4.2 Educational services architecture

The diagram below (Figure 4.1) is the design of our architecture. Our solution inserts a layer between users and e-learning resource providers – the Educational Service

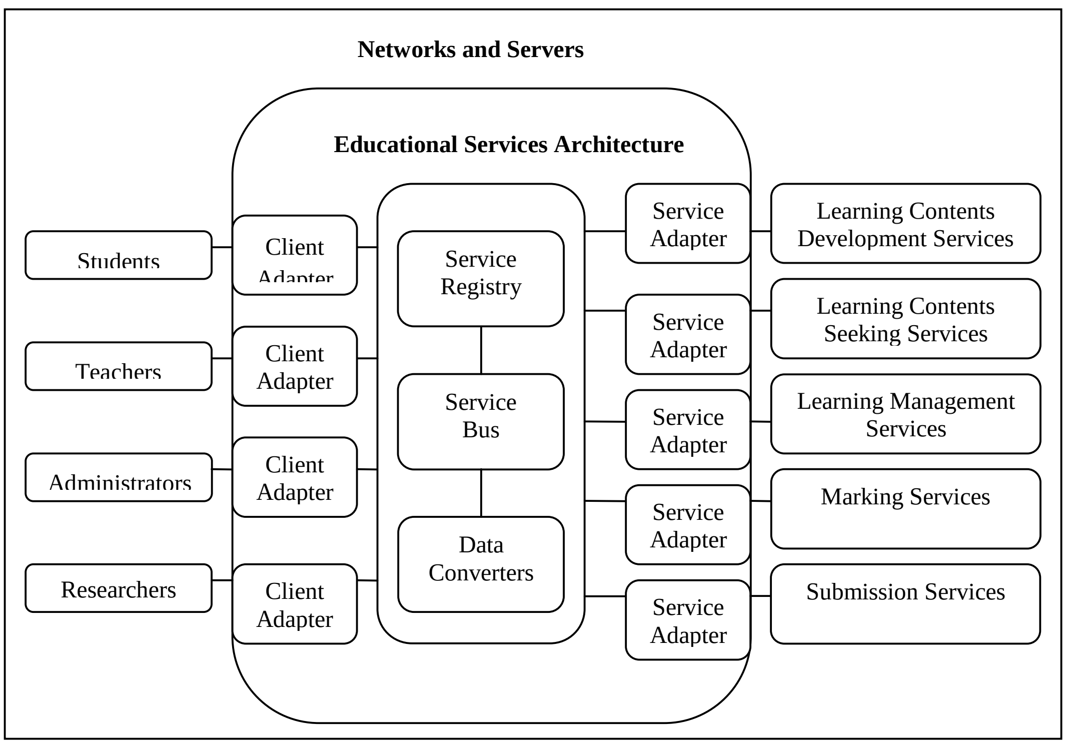


Figure 4.1: Educational services architecture

Architecture (Yang and Joy, 2011a). As a result, available resources can be better shared and reused by different users (Erl, 2007). Components of the proposed architecture are based on open standards and most of them could be implemented using Open Source technologies (Lucia *et al.*, 2008). Full details of technologies to implement each component will be addressed in section 4.5. But before that, in the rest of this section, we will introduce each component within our architecture. The following aspects are considered:

- What are the components doing?
- Why do they exist?
- Does any existing technology implement them?

Networks and Web Servers

The foundation of our educational service architecture consists of networks and web servers. The integration of these software components provides a deployment environment where educational services can actually run and interact with, other services and users (Faouzi, 2007). A combination of standard HTTP and an Apache server is a typical example of such environment (Chung and Chao, 2007).

Educational Services Architecture

There are four main components in our model: Service Registry, Service bus, Data Converters and Adapters. The details of each component are presented below.

Service Bus

The service bus acts as a data transport engine. Its main purpose is to provide message communications for interactions between service clients and providers. These messages carry educational data. This component supports the principle of interoperability in service oriented approach. SOAP (Simple Object Access Protocol) is one of the default communication mechanisms to implement interoperability in web services (Lucia *et al.*, 2008). Apache Axis2 is a popular and essential technology to support this (Bean, 2010).

Data Converters

The main role of a data converter is to transform the format of educational content in order to reuse it for other purposes. This component supports the principle of reusability in service technologies and tackles problems caused by data format mismatch (Kongdenfha *et al*., 2009). Data format mismatch refers to a situation where 'messages from one service do not fit the expectations of another service' (Chen and Huang, 2006). For example, if the output of one service is used as part of the input to another service, and these two services use different data formats, then the first service's output needs to be converted so that it meets the second service's expectations. However, currently there are few tools for converting the format of e-learning content. Lack of existing generic conversion tools can be partly explained by the myriad of different data formats for various e-learning contents (Chung and Chao, 2007).

We suggest that the conversion could contain two stages: the first one is to convert selected content to a transitional format. After that the contents in transitional format will be changed to a specific format which the target service can accept. For example, student essays, which are generated as Word format, are first converted to XML, and then converted to HTML format before a typical service (maybe the Turnitin service) is able to process them later on for detecting plagiarism (Turnitin, 2012).

Service Registry

The service registry is also called service broker, it publishes descriptions of services developed by service providers, and hence users can easily compare and choose relevant services based on the stored service descriptions (Sun and Fu, 2005). This component supports the principle of discoverability. Many technologies have been developed to enable service registries, perhaps the most well known being the UDDI registry (Papazoglou and van den Heuvel, 2007). Currently, most service deployment platforms, such as the ones in NetBeans or Eclipse IDE, support such service publication features (Simone *et al*., 2005).

Adapters

We suggest that two types of Adapters should be included, one to serve the educational services, and the other to serve the e-learning users (Li *et al*., 2009). Adapters collaborate closely with the Service bus, and their purpose is to support the principle of interoperability. However, no standard implementation technology to implement this component has been described in service related literatures (Kongdenfha *et al*., 2009). The Service Adapters enable platform independence while deploying varied educational services. They are connectors that map different service interfaces and protocols into a common model which can be accepted by the Service bus – 'A different adapter is needed for each type of application that needs to be integrated' (Faouzi, 2007).

The role of Client Adapters is to mediate between a diverse set of clients and components in the architecture. This component is also called a client gateway, and receives requests from clients and routes them to the appropriate components in the architecture (Bean, 2010). Currently, there is no single approach to the implementations of such adapters, and a variety of technologies have been adopted (Kongdenfha *et al*., 2009).

Educational resources and users

We have also included the primary educational resources that could be shared in our architecture. Educational services in our research refer to software components that provide certain functionality to support certain learning and teaching related tasks. Service providers may own many services, including the service implementations and their databases. For each service, its functionalities, operations, data types and binding information are specified in a service interface (Sun and Fu, 2005). Each user can access more than one type of service, and for each type of service there is more than one type of user who can reuse it. We have also identified four types of users who are interested in sharing e-learning resources in university environments: students, teachers, administrators and researchers. For instance, a teacher user might be interested in sharing and reusing applications for developing e-learning materials, marking coursework or detecting plagiarism. Also a teacher user is going to use a leaning delivering service to teach his course, and a group of his students are going to share this service for learning purpose.

4.3 Services principles

Our Educational Services Architecture has followed the principles of discoverability interoperability, and reusability in services technologies, which are discussed below.

Discoverability means that information about each application is described and stored in a services registry, so that potential users are able to search and compare available systems by querying the services registry (Lucia *et al*., 2008). An e-learning services registry allows systems to be described and published to students, teachers and other potential service users (Zhou *et al*., 2009).

Interoperability refers to the ability of multiple systems to operate with each other, using different technologies, platforms and programming languages. Inter-system communication is based on standard message exchange mechanisms supported by service technologies (Erl, 2007). In e-learning, interoperability means that varied educational systems are connected so that requests and responses can be carried within the standard messages, and passed around easily between those systems (Liu *et al*., 2007).

Reusability means that a given functionality within a system can be called many times and in different contexts without reimplementation (Catherall, 2005). Service technology allows existing systems to be better shared, hence making them easier to reuse (Zhou *et al*., 2009). In e-learning practices, both students and teachers are able to reuse more quality e-learning resources if they can be better shared (Su *et al*., 2007).

A service sample

The following is an example to explain how our architecture supports the sharing of a typical resource – plagiarism detection software.

Teachers require access to different plagiarism detection applications for different purposes. Sometimes, they need to handle different types of coursework, sometimes they need to use different methods to compare students' assignments against other students' assignments, or against other available web resources.

Software for detecting plagiarism already exists, including the Turnitin (2012) products for essays, and JPlag (2012) and Sherlock (Joy and Luck, 1999) for computer programming assignments. However, there are problems in sharing and reusing these applications, as they have not been well described and linked. Users may not know that they exist at all, and they cannot access all of them easily since their user interfaces differ substantially.

By using service registry, services bus, data converter and adapters in our model, plagiarism detection resources can be better described and linked, so that lecturers or teaching assistants can choose (for example) appropriate plagiarism detection software from multiple service providers to reuse for different assessment. The following diagram (see Figure 4.2), explains how the various components work together to support the task of detecting plagiarism.

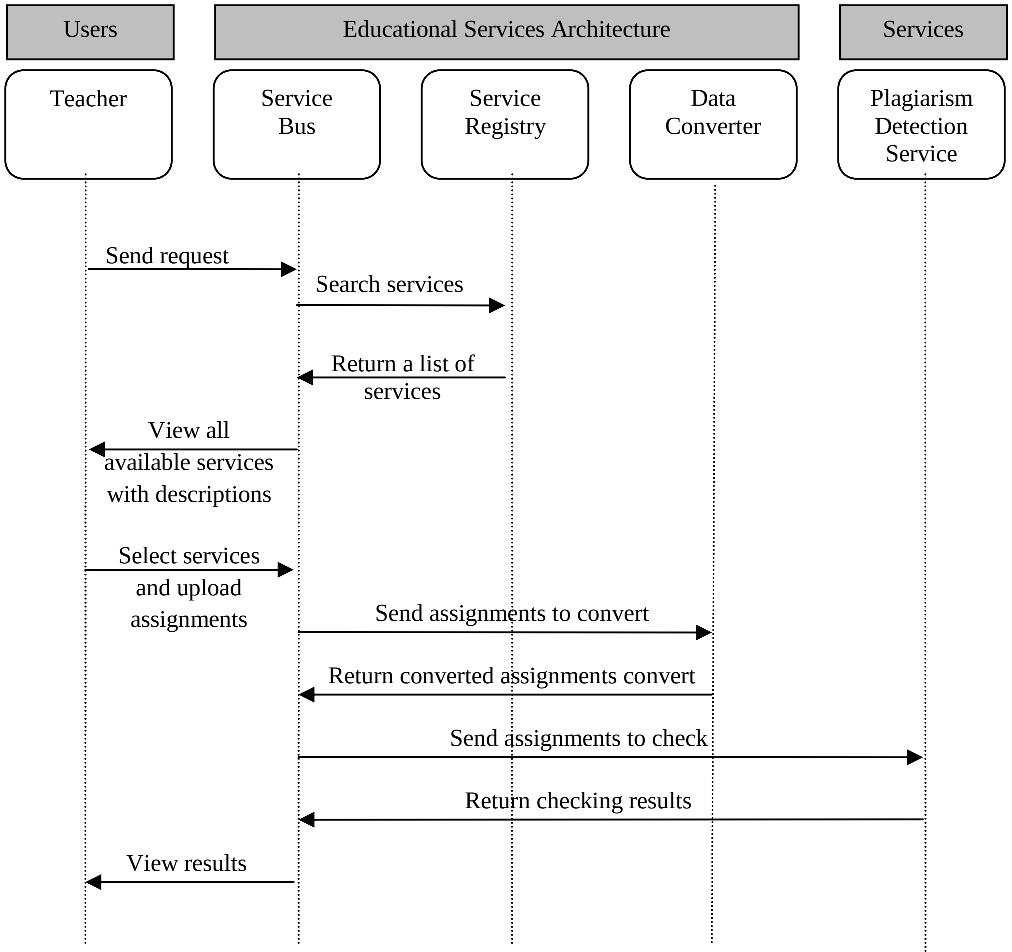


Figure 4.2: A service work flow example

In our architecture, each plagiarism detection tool is wrapped as a service – for example, the Turnitin service, the JPlag service and the Sherlock service. Details about each service are stored and published in the service registry (Papazoglou and van den Heuvel, 2007). As the work flows diagram (Figure 4.2) above illustrates, lecturers or teaching assistants will first send a request to use a plagiarism detection service to the Service bus, which in turn will contact the service registry, and return a number of available services with descriptions. Users can then make selections simply between these services depending on their needs (Zhou *et al.*, 2009). The service bus will pass messages containing student assignments to the service that has been selected, which will then process the assignments and return the detection results to users via the service bus. If it is necessary, the data converter will convert the format of the coursework before it is sent to the selected service. By using the data converter in the architecture, the format of the coursework can be converted, so that it can be easily reused in any plagiarism detection application (Bean, 2010). As users might access these plagiarism detection services in different locations at different times, and these services might be hosted on different servers by different providers, the current users and available services will change dynamically over time (Chen and Huang, 2006). For these reasons, we also suggest that both service adapters and client Adapters should be adopted in our architecture (Section 4.2). However, we have not included the adapters in the work flows diagram, as they are optional components, we assume that services and users have been connected straightforwardly, and are operating properly via our architecture.

4.4 Technologies to implement the architecture

This section presents and evaluates current available technical products that support the implementation of our proposed architecture. We have listed some of the typical ones which are still alive below.

4.4.1 Network and web server

Currently, there are many web servers that allow applications to get access through the Internet (Quartel *et al.*, 2007). A combination of standard HTTP and Apache Tomcat server is a typical configuration to support the deployment of our proposed services (Chung and Chao, 2007). Compared with the commercial web servers for example the iPlanet from Oracle (2012), Tomcat (2012) and Glassfish (2012) are Open Source with online accessible technical supports.

4.4.2 Service registry

Many registries have been developed for storing and retrieving WSDL documents by following the UDDI standard (introduced in Section 2.3.3). Some service development and deployment platforms, such as the ones in NetBeans or Eclipse, have their own built in service explorers for services publishing and discovery. Alternatively, large services technology venders below have also developed even more powerful registries.

IBM WebSphere Service Registry

WebSphere Service Registry is a highly recommended comprehensive registry that allows WSDL documents to be loaded, classified, and searched follows the latest UDDI standards. It also reports the states and changes of each service during their lifecycles. However, it is not Open Source, and requires WebSphere Application Server to be installed first, which is very expensive at the moment (IBM Registry, 2012).

Oracle Service Registry

Oracle Service Registry is another successful but expensive product to support web services publishing and discovery. It follows not only the UDDI standard but also the XSLT standard for data transformation (will be introduced in section 4.7). Oracle registry also has 'Data Accuracy & Quality enforcement mechanism' that ensures every connected service is accurate and up-to-date. It is also platform-independent, and 'can be deployed in almost any Java environment and works with all popular database systems' (Oracle Registry, 2012). However, install and maintaining it is not a straightforward task as it is a commercial and heavyweight product.

Membrane SOA Registry

As different as other registries, Membrane is lightweight and Open Source. Again, it allows services to be registered by providing their valid WSDL files, it also contains feature which reports changes and versions of each WSDL file in the registry

(Membrane Registry, 2012). However, current version of Membrane does not follow the UDDI standard for service lookups or categorisation.

4.4.3 Service bus

The most straightforward product perhaps is the SOAP engine from Apache Axis2, which processes SOAP messages between web services and their clients (will be introduced in section 4.6). However, only supporting the exchange of messages is not enough, Enterprise Service Bus (ESB for short), which contains even powerful features has been introduced by a number of service venders. It supports some way of sending a service call from a user to a service provider, and then sending an answer back from the provider to the service user (Payne, 2008). The word ‘bus’ is similar as the concept ‘computer bus’, which allows applications to be ‘easily plugged in and out from the network, without the need of restarting or stop running the systems’ (Josuttis, 2007). Applications will communicate with each other over the bus, where the number of point to point connections between applications is reduced. This will make changing of applications easier, as well as monitoring their operations. Some of the well developed ESB products are introduced below.

IBM WebSphere ESB

The Java-based WebSphere ESB Enterprise Service Bus is provided by IBM and follows most open services standards. The current version of ESB supports protocols such as JMS, EJB, Web Services, REST, HTTP etc, and formats include XML, Text, delimited, COBOL, etc. WebSphere ESB has many built-in nodes that support different types of operation such as data transformation, routing, filtering, database lookup, endpoint lookup, etc. This ESB also supports collaboration with other WebSphere packages, including the WebSphere services registry, WebSphere application server, services creating and testing tools (IBM ESB, 2012).

Microsoft BizTalk

BizTalk is another commercial ESB offered by Microsoft. It uses ‘adapters’ to connect systems inside and across organisations, the main functions include message broker, application integration, and business activity monitoring. Some of the adapters are EDI, File, HTTP, FTP, SFTP, SMTP, POP3, SOAP, SQL, MSMQ, Windows SharePoint Services (WSS) adapters. Messages inside BizTalk are implemented through the XML documents and defined with the XML schemas in the XSD standard (Microsoft BizTalk, 2012).

Oracle ESB

The Oracle Enterprise Service Bus is again another commercial product which provides a loosely-coupled framework for inter-application messaging. It supports multiple protocol bindings for message delivery, including HTTP/SOAP, JMS, JCA, and WSIF. Similar as the other ESBs, this product also contains application integration features including connectivity of services via SOAP, document transformation, management and monitoring of services operations, and visual representation of end-to-end service relationships (Oracle ESB, 2012).

Apache ServiceMix

ServiceMix is an open-source ESB provided by Apache. It can be run on Java SE or a Java EE application server, and supports protocols include HTTP/S, JMS, FTP, SMTP, XMPP, RMI, CORBA, etc. Like other ESBs, the main purpose of ServiceMix is to support communications between pluggable services which are provided by third parties. The major tasks include providing distributed processing, intelligent routing, security, and dynamic data transformation (Apache ServiceMix, 2012).

Open / Glassfish ESB

Glassfish ESB (or called Open ESB) is another Open Source enterprise service bus which is developed by Sun Microsystems. It contains packages for data transformation, orchestration and connectivity and supports collaborations with HTTP, Web services, JMS, databases, SAP, IMS etc. However, technical support and future maintaining on Open ESB is hard to predict since Sun Microsystems was acquired by Oracle in 2010 (Open ESB, 2012).

4.4.4 Data converters

Many data converters to convert computer based data from one format to the other have been developed. The followings are *typical* tools available over the Internet to support the conversions of texts, images and media for general purposes.

Text converters

Many Open Sources online text converters exist and support major formats, including PostScript, PDF, HTML and so on. Popular ones include:

- Convert PDF to Text (www.convertpdftotext.net)
- TEXT-IMAGE (www.text-image.com)
- PDF Converter (www.freepdfconvert.com)
- Convert PDF to Word (www.pdfonline.com)
- PDF to PowerPoint (pdfconverter.com)
- HTML Code converter (www.htmlconvert.net)

Image converters

There are many Open Source on-line image converters which support over 50 major image formats, including BMP (Microsoft Windows bitmap), GIF (CompuServe Graphics Interchange Format), JPEG (Joint Photographic Experts Group JFIF format), PNG (Portable Network Graphics) and so on. Popular ones include:

- Online Utility (ww.online-utility.org/image_converter.jsp)
- Online Image Converter (www.coolutils.com/online/image-converter)
- Free Image Converter (www.freeimageconverter.com)
- Image Converter (www.convertimageformat.com)
- Image Converter Plus (www.imageconverterplus.com)
- ImageMagick: (www.imagemagick.org)

Media converters

Again, there are lots of Open Source on-line media converters exist and support over 50 major music, video formats, including MP3, MIDI, MPEG, AVI and so on. Common ones include:

- Media Converter (www.mediaconverter.org)
- Online converter (www.online-convert.com)
- Media Converter (media-converter.sourceforge.net)
- YouTube Converter (www.clipconverter.cc)
- Media Converter (www.mediaconverter.org)

However, most current tools do not support the conversion of e-learning data, including the presentation slides, e-tests and questions, learning objects and so on. Lack of existing generic conversion tools can be partly explained by the myriad of data formats in various e-learning contexts.

4.4.5 Adapters

Adapters are software components that allow messages to be easily sent out from or received into the services providers and clients. Currently, there are few standard technologies mentioned in the literature which implement this component. However, large service vendors such as Microsoft have become interested in this area since 2010.

They are developing a number of general products including FILE, FTP, HTTP, POP3, SMTP and SOAP adapters. Other business adapters have been introduced such as PeopleSoft Enterprise, JD Edwards OneWorld XE, TIBCO Rendezvous, TIBCO Enterprise Message Service (Microsoft BizTalk, 2012). However, there is no well developed adapter available currently to support e-learning.

4.4.6 Evaluation on current technologies

The core component in our Educational Services Architecture is the *Service bus*, as it allows other components to be connected with each other. *Adapters* are optional components in our model and they are implemented only if the clients or services require so. The integration of these two components allows resources to be better interoperated. Collaboration between the *Service bus*, *Service registry* and the *Adapters* enable e-learning resources to be better linked and discovered. The cooperation between the *Service bus*, *Data Converter*s and *Adapters* enables e-learning resources to be better reused. Hence, the principles of discoverability, interoperability and reusability in service technologies are followed.

There is not too much development of service adapters going on, only a couple of organisations appear to be working on this currently (Li *et al.*, 2009). In the domain of e-learning, further developments are required on developing registries which publish e-learning services, converters that can process e-learning data in particularly (details about data types are discussed in section 3.6), adapters that better connect e-learning applications with our service bus.

Most of our proposed architecture can be implemented by using Open Source technologies, which following service standards WSDL, SOAP and UDDI (Papazoglou and van den Heuvel, 2007). Technologies to implement the service registry and services bus have become mature nowadays, in particular for general and business purposes.

However, due to the nature of our research, namely sharing educational related resources, these implementation technologies still require further modifications and development. We will evaluate our proposed architecture in depth in Chapter 6 later.

4.5 Technologies to develop e-learning services

As suggested in the literature, services design should consider the following topics (Kongdenfha *et al*., 2009). Our works have only addressed these in Italic, as the others are fundamental but are not related to our research motivation – improving the sharing of our current educational resources.

- *Services description*: *interfaces, implementation*
- *Data management: data representations models, data storage, data processing (mapping and conversions),* semantic data
- *Communication: interaction patterns (protocols)*
- *Services Management: discovery*, composition
- Security: Authentication (service requesters), authorization (access control), privacy, trust
- Qualities of service: messaging ordering, guaranteed delivery, best-effort delivery, high availability capability

In general, existing e-learning tools and systems can be wrapped as services over the developing products, by creating WSDL files to describe each of them. These products then create service clients and deploy them to suitable servers, so developers can test them, and users can make use of them as clients. Additionally, some products have considered services discovery and data mappings too. Further more, new e-learning services can be developed from scratch by using languages including Java, C or PHP (Blomberg and Evenson, 2006; Chen and Huang, 2006; Curbera *et al*., 2002). Currently, services can be developed by visiting a one stop shop service development platform, or using a set of separate development tools. The followings summarise some of the mature, all in one products that support service creations and deployment comprehensively.

Apache

Apache Axis or Apache Axis 2 is a framework which enables Web services to be created and run. It supports the following tasks (Apache Axis, 2012).

- Create service descriptions using WSDL, and store them into WSDD directory
- Create service implementation classes using JAVA
- Allow new services to be uploaded, activated, stopped and updated using a Web administration tool
- Send and receive SOAP messages
- Support WS-Addressing, WS-Policy and WS-Security
- Allow data mappings in XML and Java

Altova

Altova XMLSpy® includes a number of tools to support the development of Web services applications (Altova, 2012).

- Graphical WSDL editor
- Designing WSDL documents
- Editing WSDL documents
- Validating WSDL documents
- SOAP client & SOAP debugger
- Interpreting WSDL documents
- Generating & sending SOAP requests
- Debugging SOAP messages

IBM

IBM Rational® has developed a number of tools to support service development (IBM Rational, 2012):

- Web Services wizard to create, deploy, test, and publish Web services bottom-up from existing applications, and top-down from WSDL
- Web Services wizard to create client interfaces for a Web service and to test it:
- Web Services Explorer to discover and publish Web service descriptions with a UDDI Registry
- WSDL validator to test services.

Stylus

Stylus Studio® is also a popular framework, including a Web service call composer, WSDL editor and data mapping tool and supports the following tasks (Stylus Studio, 2012).

- Testing and debugging of Web services, WSDL files
- Generate SOAP messages
- Search/Browse UDDI registries, invoke Web service calls, receive/preview result
- Invoke web service methods

To summarise, Table 4.2 below describes each product in terms of their main features and supporting tools, most of them are commercial products except Apache Axis. They all can be applied to develop e-learning services directly.

Tools / Features		Service Builder	Deployment & Discovery	Validator & Tester	Data mapping & Process
Apache	WSDL2Java	✓			
	Java2WSDL	✓			
	Web Service Deployment Descriptor		✓		
Altova	SOAP Client	✓			
	SOAP Debugger			✓	
	Graphical WSDL Editor	✓			
IBM	Web Services Wizard	✓		✓	
	Web Services Explorer		✓		
	WSDL Validator	✓		✓	
Stylus	Web Service Call Composer		✓	✓	
	WSDL Designer	✓			
	Data Mapping Tool				✓

Table 4.2: Overview of service development products

4.6 Technologies to process educational data

Processing of computer data can mean many different tasks, for example data translation, import / export, transformation, transition, migration, extraction, decoding, integration, re-formatting and so on (Vittorini *et al.*, 2007). In Section 3.6, we addressed the technical developments that support the presentations of e-learning data. In this section, we highlight some of other fundamental technologies which have potential to address other aspect of data processing – data mapping and integration.

Data mapping is a process of developing mapping between two different data models. It is a first step for further data integration processing. It is an important step for departments or organisations to exchange data between each other. There are many standards and tools, and below is a selection of example standards currently available.

ASC X12

ASC X12 is a popular standard which has been applied in business domains to support data transactions. It contains a collection of X12 XML schemas for health care, insurance, government, transportation, finance, and many other industries. Over 350 companies in the U.S have been the ASC X12's members by 2010. However, it does not support e-learning data currently (ASC, 2012).

XSLT

XSLT is an XML-based standard for converting data between different XML schemas or to convert XML data into web pages or PDF documents. The transformation is achieved by a set of template rules, the details of how it works is described in its manuals (XSLT, 2012).

XQuery

XQuery is a language for query XML data which provides a flexible means for data abstraction. By using XQuery in Stylus Studio® Data Mapping tool, XML data returned from a Web service can be easily saved and used as input for further data mapping and integration. XQuery can also be used to extract information to convert XML data into XHTML files, and search web documents for relevant information. XQuery also supports other standards including XML Namespaces, XSLT, XPath, and XML Schema (XQuery, 2012).

In the domain of e-learning, further developments are also required on the standards to represent educational data (see Section 3.6 for details), as these components may require customised implementations because they must cater for a wide variety of different data formats and platforms (Kongdenfha *et al.*, 2009). It has also been suggested that semantic and ontology languages will make data mapping a more automatic process in the future, as this process ‘will be accelerated if each application performed metadata publishing’ (Bouzeghoub and Elbyed, 2006). However, there is little discussion of such data processing in e-learning. Educational data may be presented in varied formats, but existing deployment platforms cannot handle this well. For example, there are issues relating to how a search engine can recognise these formats, how it can do the search, and if it is necessary, how it can convert and or integrate the format at run time. Currently, there are standards to support data mapping, integrations and conversion, such as XSLT and XQuery (Banlue *et al*., 2010). However, in terms of e-learning data, few technologies support this. We suggest that to find optimal, generalisable solutions for implementing these components requires more research in the future.

4.7 Summary

In this chapter, we have proposed a novel educational services architecture to support the sharing of e-learning resources indentified in chapter 3. We have also provided a literature survey to present current implementation technologies that support the developments of our proposed architecture and indentified e-learning resources.

Research question 3 is answered in this chapter, as we argue that our proposed Educational Service Architecture has the potential to support the sharing of e-learning resources, by better describing, structuring and connecting current e-resources, such as e-learning materials, students record systems, and applications to support learning and assessment tasks, by following the principles of discoverability, interoperability and reusability in service technologies.

To summarise, our educational service framework has been developed. Chapter 5 is concerned with evaluating the performance of our proposed framework via a case study from users' point of view, where we will compare the differences before and after our services framework is introduced. Chapter 6 will evaluate our proposed framework from a technical perspective via another case study.

Chapter 5

Users' Experience on Sharing Educational Resources

This chapter evaluates the service approach we have proposed in chapters 3 and 4, from users' points of view. Case study experiment 2 has been conducted. It aims to compare the effectiveness of our service approach with that of the use of current technologies. Research question 4 is considered in this study:

Has the sharing of educational resources been improved via our services framework?

In this chapter, we will start with introducing the design of our experiment, follow by presenting each experiment activity in details in terms of methodology, findings and discussion.

5.1 Introduction

As we have studied earlier, many different types of educational resources have been are developed and are Open Source. Most of them can be wrapped as e-learning services (Figure 3.3). Our proposed educational services architecture (Figure 4.1) is able to connect these services together, and support the data exchange amongst them. Ideally, we should implement all of the e-learning services indentified, together with our educational services architecture first, before we start to collect feedback on the effectiveness of our framework from the potential users. However, due to the limitations on time, technical support, students and staff we can get access to, we have decided to simulate part of our services framework, and conducted a case study experiment to examine how well the sharing of educational resources has been improved via our services framework.

The case study means we have invited volunteers to take part in our experiment from only a typical UK university. In the simulation, we have only focused on one type of educational resources – e-learning materials and their repositories. In order to study the improvements of our proposed framework, we have decided to simulate not only the service approach, but also the approach that use of current technologies. Hence we can compare the effectiveness between each other easily.

In order to help us to design the experiment activities and collect data, we have divided research question 4 into the following hypotheses and sub questions:

Sub question 1: How well has the sharing of educational resources been conducted using current practices? (SQ1)
Sub question 2: What benefits can the service approach bring that the current approach does not? (SQ2)
Sub question 3: Why is the service approach not good enough? (SQ3)

Hypothesis 1: Our services approach is able to more quickly discover useful learning materials than the current approach (H1)

Hypothesis 2: Our services approach is able to more easily discover useful learning materials than the current approach (H2)

The following table (Table 5.1) provides an overview of the methodology applied in this case study experiment (or called Exp 2 for short).

Experiment 2 Methodology Overview			
Research stage	Research question 4		
Phases	1: Understand the current practice	2: Experience with service approach and current approach	3: Reflection on both approaches
Hypotheses and sub questions	SQ1	H1, H2	SQ2, SQ3
Experiment activities	Individual interview	Use ST and CT; measure speed; fill in ST and CT questionnaires	Individual interview
Instruments	Interview questions; voice recorder	ST and CT prototypes; time and click counter; usability questionnaires	Interview questions; voice recorder
Data collection	Interview transcriptions	Time taken for using CT and ST; number of clicks for using each tool; questionnaires responses	Interview transcriptions
Data analysis	Content analysis	14 T-tests	Content analysis

Table 5.1: Overview of methodology in experiment 2

Experiment 2 contains three phases. The first phase is individual interviews, it aims to gain a picture on how well e-learning resources have been shared and reused in current practice, together with the common weaknesses people concern about. This understanding also helps us to represent the current approach people are going to apply in the next phase. In phase 2, we conducted a simulation that compares the effectiveness of our service approach with that of the use of current technologies. During the simulation, we asked volunteers to perform a common task: discover e-learning materials from a number of popular repositories, by using the services approach and the current approach, where the service one has included the main features of our service framework, and the other has not. We also collected usability data and feedback from the volunteers after they have experienced with both approaches. In the last phase, we performed individual interviews again, and asked volunteers to reflect on both approaches, in order to indentify improvements or benefits our service framework can bring, together with its current limitations.

All the qualitative data are collected and analysed in phases 1 and 3, and all of quantitative data are handled in phase 2. After we introduc the design of our case study, in the rest of this chapter we present our research in each phase in details in terms of methodology and findings. The methodology will be presented in full detail, in particular the sub research questions and hypotheses we have applied throughout the study. The questions we have actually asked during the interviews, the searches each participant has performed during the simulation, and the statistical tests we conducted to analyse quantitative data, are also included in Section 5.3. Finally, in Section 5.4 and 5.5, we compare the findings we have discovered in the different phases, and discuss how our findings have contributed to the research, and evaluate the limitations on our research methodologies.

5.2 Phase 1: Understand the current practice

5.2.1 Methodology

Sub question 1: How well has the sharing of educational resources been conducted using current practices?

Sub question 1 has been applied to guide the study in phase 1. Seven academic staff across different disciplines at the University who have experiences on handling e-learning resources were invited for the semi-structured interviews. We used the following open ended questions to understand how people think about current practice and weaknesses surrounding the sharing of educational resources.

- What do you think about the use of e-learning materials?
- What do you think about search and discovery of e-learning materials?
- What do you think about the sharing of educational resources in current practices?
- What do you suggest to address these limitations?

Due to the nature of information we were seeking, we adopted qualitative analysis procedures to understand the current problems in depth (Yin, 2009; Brenner *et al*., 1985). This content analysis consists of five stages.

Stage 1: *Generating topics*

By reviewing the interview transcriptions, we identified all the issues that were mentioned by each member of staff. In order to describe each of them, we highlighted the keywords, and use short sentence to summarise what has happened. Some of the topics are listed as below, for example:

- Not be aware of
- Not have been well organized
- Technical difficulties to share resources
- Sharing is not enough

Stage 2: *Collecting quotations to support each issue*

We went back to the interview transcriptions again, and collected the quotations that were relevant to each topic we have identified above. For example, for 'technical difficulties', most of the interviewees discussed this topic, but each addressed different aspects of it, including formatting, copyrights, size of the video files, and so on. We also counted how many people have mentioned each issue.

Stage 3: *Interpreting the quotations to describe each issue*

At this stage, we analyzed the interview data to identify the main resources sharing issues, together with potential solutions to address them, if they were mentioned. We first examined the meanings of each quotation, to determine if there are common issues, then we used a short sentence to describe what is going on, and used the interview data to help us arrive at a form of words for accurately describing each issue and suggestions to deal with them. After that, we also counted how many people have mentioned each issue.

Stage 4: *Classifying the issues*

At this stage we grouped the identified issues into categories, or 'themes'. This will help us to further evaluate the findings in later section xxx.

Stage 5: *Validating the findings*

At this stage, we compared the findings against the interview transcriptions to check if we have misinterpreted any quotation, or missed out any important quotation.

5.2.2 Findings

According to the data we have collected from the interview transcriptions, we identified a number of problems staff concern about currently, and some of the potential solutions are also included. These problems are classified as the following.

Theme 1: Discoverability

The most common problems is ‘being aware of what educational resources are out there’, 4 out of 7 staff have agreed with this, most users cannot benefits from these quality technologies because ‘they don’t know what exist at all’.

4 out of 7 respondents have mentioned that current e-learning resources have not been well organized and people don’t have time to discover, compare and choose them. One member of staff commented that ‘It is hard to find the materials what you are looking for, I am not sure it is best organized. I think it needs to be better categorized, so you can quickly find what you want’. Another lecturer also stated that ‘We don’t have time to compare our teaching materials with other sources, as we are too busy’.

The third weakness is that current learning resources have not been described properly by the providers. For instance, a member of staff who is in charge of developing e-learning resources for business course has told us that, students prefer to learn from different types of resources, they have always tried to choose the resources that fit best with the subjects, to allow learners get most benefits from them. However, they are not sure that if the types of resources have been described properly or not in teaching all the subjects. He has outlined that ‘For Accounting, we got many multiple-choices question banks with feedback on whether that is correct or not and why, that is what they need to practice on this subjects.’ ,‘In Marketing, we have not got any multiple-choices question, but we got lots of video and interviews with actually marketing directors from companies, and ask them questions related to the study notes’, ‘We also got one module is about Modeling, some students do struggle with that, they found it really hard to understand it from words or pages, we have videos to explain what is happening, students do find it very helpful to understand the concepts.’

Theme 2: Interoperability

Most people believe that there is not enough sharing going on. For example, 'Google is not good enough for searching', 'At the moment, we cannot find everything from there'. One participant has expressed that 'sometimes you want something quick, but there are so many places, I don't think they are connected'. Another commented 'We aim to improve the sharing and communications among the people, to build more activities around them. For students that are far from us, I think it is quite nice to have more technologies to help them feel part of the students' community'

Another common issue is the accessibility of current resources. Firewall is an increasingly important issue. A member of staff from a distance learning programme stressed that 'We have students from 40-50 different countries who take part in our MBA programme. If they are based in Europe, they have access to all learning resources, I think is not a problem, but if you are in China, Sudan, Turkey, there are different problems depends on the countries, such as links go down very frequently in Sudan, YouTube has been blocked in China and Turkey. Students can't access the contents hosted on our server'. Formatting is another problem. Another member of staff maintained that 'In the past, we have bought many not open resources externally to support our teaching in accounting, such as the question banks and tests. However, these materials need completely different environment than we have used here, we can't run them at all due to the inconsistency in formatting.

Theme 3: Reusability

Currently, both learners and teachers do not have enough motivation to share educational resources. Most users can not see the added values or benefits to their learning and teaching experience. They might not want to try the latest e-learning technologies. A member of staff commented that 'The technologies is not a problem, the problem is why teachers should spend a lot of time on the technologies. Most lecturers are judged by research outputs rather than teaching. They don't use these technologies as they can't see the benefits of them, they will agree with you that it was a good idea, but they are not going to do it, because they are not in the routine to do that, they have not been told to do it, they don't have time to do it'. One respondent also mentioned that 'For encouraging students to use the system, it depends very much on the nature of students. There are expectations, so each time there is a step change on what we are doing with the technologies, students who are used what was there before, often don't want to use the new things.' Some people also believe that sharing educational resources might put them at risk. For example, one staff has argued that 'Do you think people are willing to share? I don't think so, university might believe that this will lose students, as our materials are all available online, free of charge, the university might want to control the power'.

Other issues

There are also many management issues, such as buying resources, encouraging people to use these resources, and telling them how to access to these resources.

One issue is that users have difficulties with learning to use new e-learning resources. It is even more difficult for inexperienced users. For example, a participant has stated that 'You know SiteBuilder is very straightforward to use, but for people who use them first time, nothing is automatic for them. It doesn't work like using other Microsoft applications'. It is a barrier, as people don't have a vision of how to use new tools, in particular if the procedures of using the new tools are very different from these they are familiar with. A lecturer has stated that uploading a video file to SiteBuilder is not straightforward, because 'You have to download it, save it, go to SiteBuilder, upload the file to SiteBuilder server, and create a link to that file; these are difficult for most beginners.' One participant has noted that 'The problem is a lot with students' attitude with technologies: Learners usually have short term pain for long term solution, you ask people to move from what they do routinely to do something new and different, it will take quite a long time to build up skills, the whole thing to use technology in teaching is very complicated, the problem rely on accessing the technologies, it is management problems, it is leadership problems.' One respondent also mentioned that 'For encouraging students to use the system, it depends very much on the nature of students. There are expectations, so each time there is a step change on what we are doing with the technologies, students who are used what was there before, often don't want to use the new things.' Another member of staff commented that 'The technologies is not a problem, the problem is why teachers should spend a lot of time on the technologies. Most lecturers are judged by research outputs rather than teaching. They don't use these technologies as they can't see the benefits of them, they will agree with you that it was a good idea, but they are not going to do it, because they are not in the routine to do that, they have not been told to do it, they don't have time to do it.'

Our current e-learning staff highlighted that both learners and teachers do not have enough motivation to share educational resources. Most users can not see the added values or benefits to their learning and teaching experience, by sharing the e-resources, as the results, they might not want to use the latest e-learning technologies. Some people also believe that sharing educational resources might put them at risk. For example, one staff has argued that 'Do you think people are willing to share? I don't think so, university might believe that this will lose students, as our materials are all available online, free of charge, the university might want to control the power.'

To summarise, sub question 1 - How well has the sharing of educational resources been conducted using current practices - is answered. The findings have drawn a picture on how well e-learning resources have been used and shared in current practice, in particular the problems they have, and potential solution to cope with those problems. This exercise suggests that there are weaknesses in the current approach to share e-learning resources, in particular the e-learning objects stored in many repositories. We have classified people's opinions into the following two levels. We use the knowledge we have gained from this study to guide our work in phase 2.

Level 1: Current status in sharing educational resources

Nowadays, the number of technologies to support e-learning is growing. These tools and the data they rely upon are valuable resources in supporting different aspects of the complex learning and teaching processes, including designing learning content, delivering learning activities, and evaluating students' learning performance. However, people/users cannot fully benefit from these resources as they have not been shared effectively and efficiently.

- Most users are unaware of many e-resources
- People are not willing to share and use technologies, they can't see the benefits of doing so
- Learning to use new technologies is painful for most beginners, as they don't have the vision of how to use them, and they don't have the skills to overcome technical difficulties
- Current learning resources providers have not described their resources properly
- Educational resources have not been well organised, it is difficult and time consuming to discover, compare and choose e-resources
- In general many resources do not interoperate, and it is common for tools to rely on different technologies, which further exacerbate the problem.

Level 2: Problems and suggestions in sharing e-learning materials

Today thousands of free e-learning objects have been developed and made available online across the world. Repositories to store these objects are gradually increasing in maturity, and more and more people have become interested in using and reusing them. However, it is a challenge for most users to find high quality and useful materials effectively from these repositories. Our findings have suggested the following difficulties in sharing e-learning materials.

- Current sharing is not enough. For example, Google is not good enough for searching e-learning materials.
- As beginners, users do not know where materials are, many repositories have not be aware of by many people. They have to spend a lot of time to learn and use these repositories.
- The materials present in repositories are often poorly described and indexed, and they cannot access all of them easily since their user interfaces differ substantially. As the result, people tend to lose interest and fail to find the materials they want by using current approaches, even they are experienced users.
- People are not willing to use new repositories, as they can't see the benefits to do so.
- Learning to use new repositories is painful for most beginners, as they don't have the vision on how to use them, and they don't have the skills to overcome technical difficulties.

5.3 Phase 2: Experience with service approach and current approach

In this section, we are going to turn our proposed educational services architecture into practice, by simulating part of it to share a number of popular e-learning material repositories. In phase 2, we will ask potential users to experience our service approach as well as the approach that uses of current technologies. Hence, we can explore further on whether or not that our proposed service framework can bring improvements to the sharing of educational resources.

5.3.1 Methodology

During the simulation, six repositories JORUM, ARIADNE, Merlot, Math World, MIT OpenCourseWare and EduSource were included. 14 potential users, which include students, lecturers and e-learning staff across different disciplines within our institution, took part. They were asked to search and select a number of learning materials from these repositories for a given topic, by applying both the current and service approaches. The activities (see Appendix for full details) they have followed include:

Activity 1: Search and choose e-learning materials for the topic 'essay writing' from 6 given repositories, and fill in a short questionnaire to record your experiences on the first approach. Please refer to 'materials for the first approach' to start with.

Activity 2: After you have attempted the first approach, please conduct the second approach: search the same e-learning materials again, and fill in another questionnaire to record your experiences on the second approach.

In each approach, they first typed in the keywords 'writing' or 'essay writing' in the search box. Then they pressed the 'search' bottom, a list of available materials that were relevant to essay writing was generated on the next screen. Users can then view and compare them, and hence chose a number of learning contents that suited their needs. As we were not interested in which materials each user preferred, we have not applied any criteria for learning content selection in this simulation.

Based on the data we have obtained from both usability questionnaires, we then analysed their opinions on each approach, and identified which approach they preferred, how easy each tool was to use, and how significant the differences between the two tools were. Also, we counted the numbers of clicks each user has made, together with the time taken, for discovering a full list of learning materials in each approach, hence to measure the comparative speeds for discovering materials in each approach.

We used the same questionnaire for each approach, and compared the results of the two questionnaires for each respondent. In each questionnaire, there were 12 closed questions to evaluate the speed and level of ease for discovering useful materials using each tool. After users had filled in this questionnaire, which uses five-point Likert scales, we then analysed their responses by comparing the significant differences between the two questionnaires. The questions we have asked and results we have found are summarised in the next section in Table 5.3 and 5.4.

This simulation aims to collect quantitative evidence to examine the effectiveness of our proposed service approach (Cohen, 2005). The following two hypotheses are considered.

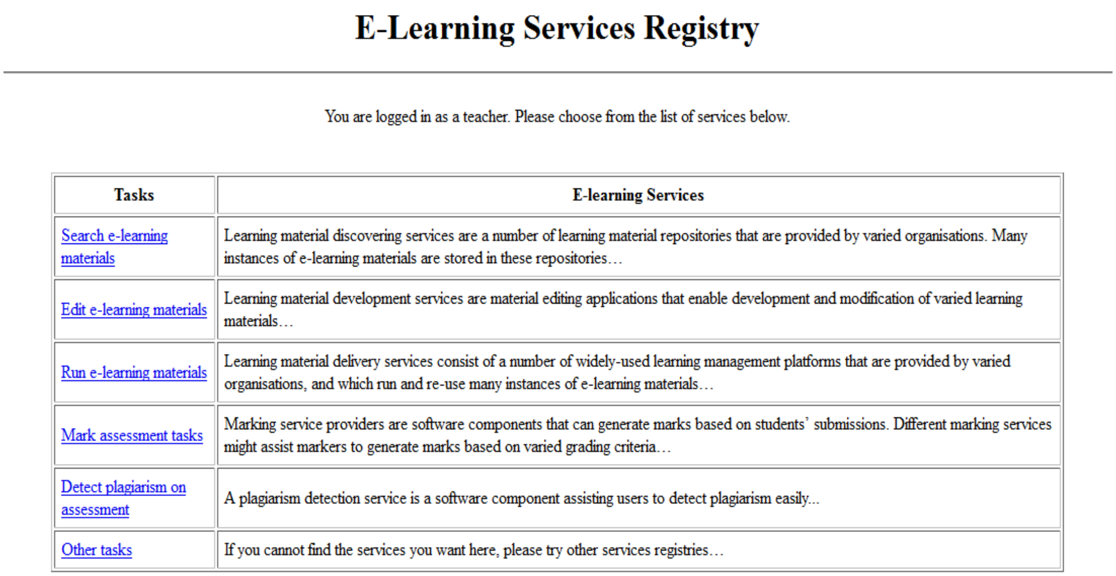
Hypothesis 1: Our services approach is able to more quickly discover useful learning materials than the current approach (H1)
Hypothesis 2: Our services approach is able to more easily discover useful learning materials than the current approach (H2)

5.3.2 Service prototype and current prototype

We use prototypes to realise each approach. The prototype representing the service approach is called *service tool* (*ST* for short), and the one without services features is called *current tool* (*CT* for short). They all allow the user to search for materials from a number of repositories. However, The CT was essentially a shell for the search software provided individually by the repositories; the ST was a prototype implementation of our service architecture. The idea of ST is similar to how people search a single interface for scientific publications from several databases.

The current approach suffers from the limitations on sharing educational sources we identified from the literature review in chapter 2 (see Section 2.1.2, 2.1.5, 2.4.1 and 2.5) and staff interviews in section 5.2.2: current resources have not been described well enough. In CT, the descriptions of repositories and the materials contained in each repository are not discoverable or comparable straightforwardly from the users' perspective, and there is no connection at all between these repositories (see Figure 5.4). Conversely, in the service approach, e-learning resources are better described and organised. In ST, each repository is categorised as a learning material discovering service (see Figure 5.1), explanations on each repository are presented, and users can compare and search materials from a number of repositories at the same time, because all of them are linked (see Figure 5.2). We have also assumed that users are teachers and learners (rather than developers) in this simulation, and this has informed how we presented the explanations and descriptions. We claim that our service approach supports resource discoverability and interoperability, by allowing a set of varied resources to be collected and compared together in one go, where this has not been proposed or implemented before in current practice.

In the rest of this section, we will present the ST and CT in detail. In ST, all the repositories are categorised as the learning material discovering service (Figure 5.1), each repository (e.g. MERLOT, ARIADNE or JORUM) is wrapped as a service – for example, the Merlot service, the ARIADNE service and the JORUM service. Details about each service are stored and published. Teachers and learners can compare many repositories at the same time, and choose appropriate repositories from multiple service providers based on their needs. Differences between the repositories have been described clearly, in terms of service description, languages, subjects, and user reviews. Because these services are linked together, searches can be performed in one go, and the search results are presented in a single list, as illustrated in Figure 5.3.

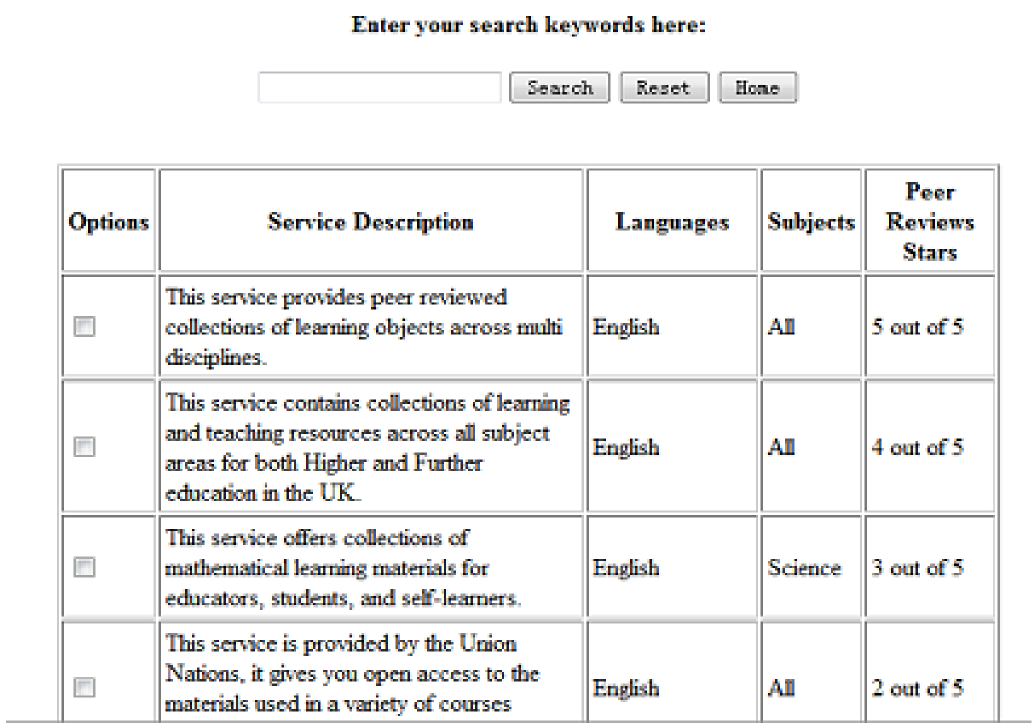


E-Learning Services Registry

You are logged in as a teacher. Please choose from the list of services below.

Tasks	E-learning Services
Search e-learning materials	Learning material discovering services are a number of learning material repositories that are provided by varied organisations. Many instances of e-learning materials are stored in these repositories…
Edit e-learning materials	Learning material development services are material editing applications that enable development and modification of varied learning materials…
Run e-learning materials	Learning material delivery services consist of a number of widely-used learning management platforms that are provided by varied organisations, and which run and re-use many instances of e-learning materials…
Mark assessment tasks	Marking service providers are software components that can generate marks based on students' submissions. Different marking services might assist markers to generate marks based on varied grading criteria…
Detect plagiarism on assessment	A plagiarism detection service is a software component assisting users to detect plagiarism easily...
Other tasks	If you cannot find the services you want here, please try other services registries…

Figure 5.1: Service registry as presented in ST

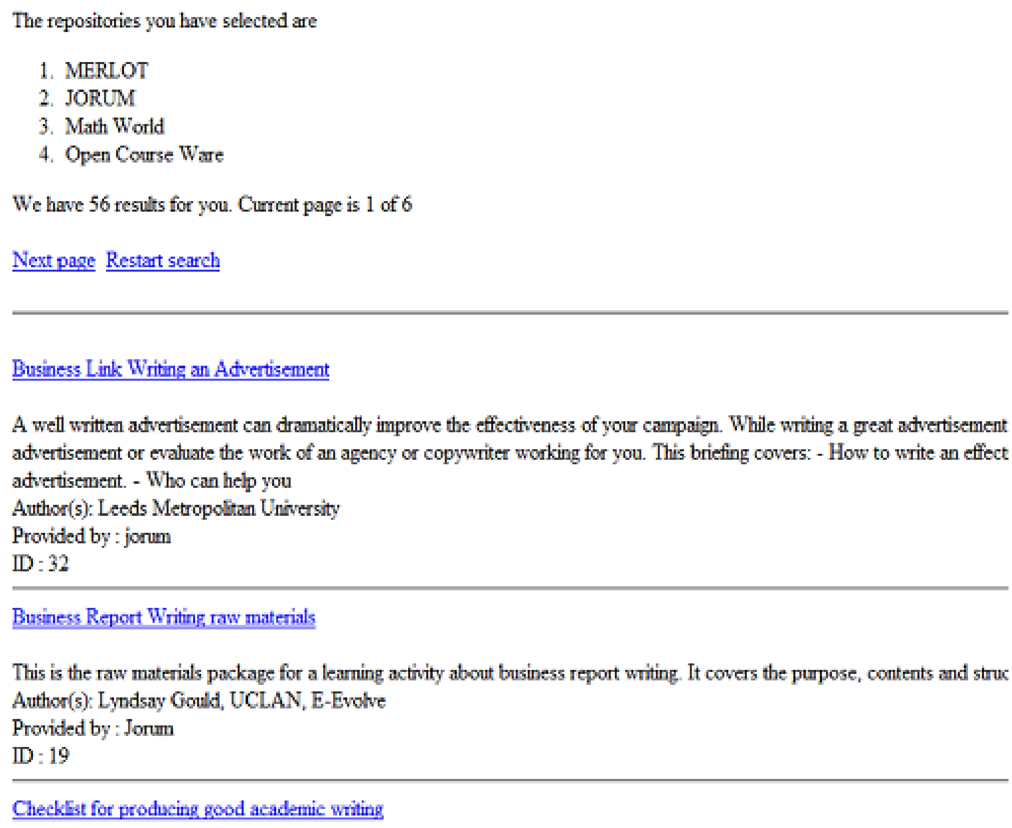


Enter your search keywords here:

Search Reset Home

Options	Service Description	Languages	Subjects	Peer Reviews Stars
	This service provides peer reviewed collections of learning objects across multi disciplines.	English	All	5 out of 5
	This service contains collections of learning and teaching resources across all subject areas for both Higher and Further education in the UK.	English	All	4 out of 5
	This service offers collections of mathematical learning materials for educators, students, and self-learners.	English	Science	3 out of 5
	This service is provided by the Union Nations, it gives you open access to the materials used in a variety of courses	English	All	2 out of 5

Figure 5.2: Repositories as presented in ST



The repositories you have selected are

1. MERLOT
2. JORUM
3. Math World
4. Open Course Ware

We have 56 results for you. Current page is 1 of 6

Next page Restart search

Business Link Writing an Advertisement

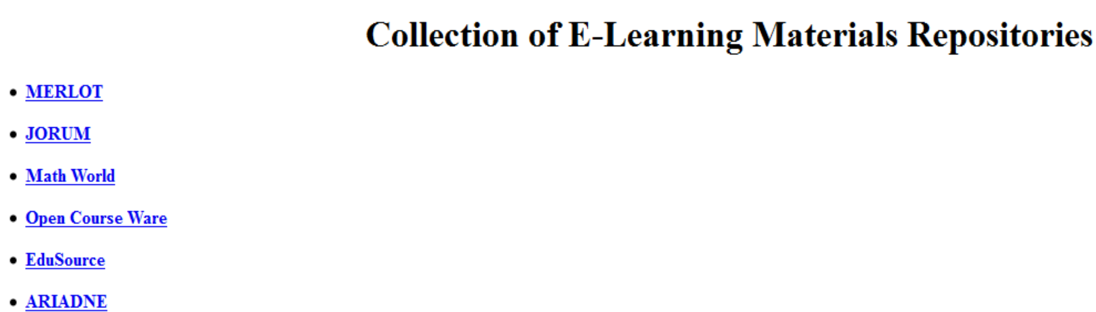
A well written advertisement can dramatically improve the effectiveness of your campaign. While writing a great advertisement advertisement or evaluate the work of an agency or copywriter working for you. This briefing covers: - How to write an effect advertisement. - Who can help you
Author(s): Leeds Metropolitan University
Provided by : jorum
ID : 32

Business Report Writing raw materials

This is the raw materials package for a learning activity about business report writing. It covers the purpose, contents and struc
Author(s): Lyndsay Gould, UCLAN, E-Evolve
Provided by : Jorum
ID : 19

Checklist for producing good academic writing

Figure 5.3: Search results as presented in ST



Collection of E-Learning Materials Repositories

- MERLOT
- JORUM
- Math World
- Open Course Ware
- EduSource
- ARIADNE

Figure 5.4: Repositories as presented in CT

In CT, users begin by visiting the ‘Collection of E-learning materials repositories’ screen (shown in Figure 5.4). They then use the links provided on the page to access different repositories separately. In this approach, people access one repository in each search. Descriptions of the individual repositories do not include comparisons between them, and the search results are presented differently for each repository. Users may encounter materials which are repeated in different repositories.

The following highlight the differences between ST and CT in terms of discoverability, interoperability and reusability (Table 5.2).

Themes	Service Tool	Current Tool
Discoverability	Structures available resources by categorising them as learning materials providing services, marking services, plagiarism detection services and so on (Figure 5.1)	Resource categorisation is not available (Screenshot is not available)
	Provides rich information to describe each repository, in terms of languages, subjects and peer reviews (Figure 5.2)	Resource description is not available (Figure5.4)
Interoperability	Links many repositories together by using only one search box, and listing all the search results on a single list (Figure5.2)	There is no connection at all amongst all the repositories (Figure 5.4)
Reusability	People are able to see other types of resources as services and are able to compare them (Figure 5.2)	People cannot view or compare other types of resources (Screenshot is not available)
	People have chances to review other repositories which are different from these they are familiar with, or from these they have been asked to use all the time (Figure 5.2)	People might not be aware of other repositories (Figure 5.4)

Table 5.2: Comparison between ST and CT

5.3.3 Findings

This section presents the data analysis we have conducted together with findings for each hypothesis.

Hypothesis 1: Our services approach is able to more quickly discover useful learning materials than the current approach (H1)

Questions addressing H1	Mean CT	Mean ST	P	Results
Which approach allows different repositories to be searched more easily?	1.79	4.86	0.0001	Service approach
Which approach allows search results to be displayed in a better way?	1.93	4.71	0.0001	Service approach
Which approach allows users to understand each e-learning material more quickly?	3.07	4.21	0.0085	Service approach
Which approach allows users to choose useless e-learning materials more quickly?	2.86	2.86	1	No Significant Difference
Which approach requires less time to discover the same amount of materials	340 seconds	54 seconds	0.0001	Service approach
Which approach requires less clicks to discover the same amount of materials	45 clicks	13 clicks	0.0001	Service approach

Table 5.3: Findings for hypothesis 1

As we have mentioned in section 5.3.1, each question in the questionnaires is measured using five-point Likert scales. After we collected the usability feedback from all the volunteers, we first converted users' opinions into scores for each respondent, where we coded score 1 ('strongly disagree') as the lowest and score 5 ('strongly agree') as the highest. We then compared the mean scores for both approaches for each question, and these are presented in the first four rows. We also calculated the *average time* and *number of clicks* taken by the respondents for each approach.

The analysis contains two stages. The first stage calculated the mean score for each question (the scores for the CT and ST are presented in the second and third columns respectively). The second stage examined whether the difference between the service and current approaches is significant, as presented in column 'P'. For example, for the first question in Table 5.3, score 1.79 suggests that most users believe that CT is not easy for searching different repositories, as the mean score is lower than 2.5. On the other hand, score 4.86 indicates that service approach is more suitable for searching in a number of repositories, as most users have chosen the option 'agree' or 'strongly agree' in the usability questionnaire.

During the second stage of data analysis, we applied 6 paired-samples t-tests to compare the differences in mean score obtained from both service and current approaches. Column 'P' in Table 5.3 presents the test results. The first 4 tests are based on the answers from questionnaires. The last 2 are based on data collected from the time and clicks counter. The mean scores obtained from the service approach are higher, suggesting that this approach is faster. A p value less than 0.05 indicates that the difference in mean score is statistically significant (Kanji, 2006), which is the case for 5 out of 6 tests, and *hence we conclude that hypothesis 1 is supported***.**

Hypothesis 2: Our services approach is able to more easily discover useful learning materials than the current approach (H2)

Questions addressing H2	Mean CT	Mean ST	P	Results
Which approach is able to show the differences between all the repositories more accurately?	2.93	3.86	0.037	Service approach
Which approach allows users to access all the search screens more easily?	2.36	4.29	0.031	Service approach
Which approach allows users to choose useful e-learning materials more easily?	2.57	3.64	0.0073	Service approach
Which approach is able to more clearly describe each repository?	3.36	3.64	0.49	No Significant Difference
Which approach allows users to decide which repositories to use more easily?	3.79	3.79	1	No Significant Difference
Which approach allows user to find out the quality of discovered materials more easily?	2.86	3. 50	0.13	No Significant Difference

Table 5.4: Findings for hypothesis 2

For hypothesis 2, we applied the same approach for data analysis. Based on the answers from both questionnaires, 6 2-sample t-tests were applied to identify which approach most people prefer, and half of the tests supported the service approach (see Table 5.4). This indicates that *hypothesis 2 is partially supported*. We therefore argue that ST, although the current version is not perfect, does improve the descriptions and discovery of e-learning resources compared with CT.

*To summarise, the overall findings show that the service approach is effective for describing and discovering learning materials from their repositories***.** However, the insufficient clarity with which the resources and repositories are described offsets this generally positive evaluation. The second run of interviews, which will be presented in phase 3 of this experiment, are then conducted to help us to better understand that why service approach is not good enough and how we could improve our proposed service approach in the future.

5.4 Phase 3: Reflection on both approaches

5.4.1 Methodology

This exercise focuses on the following two research questions.

Sub question 2: What benefits can the service approach bring that the current approach does not? (SQ2)
Sub question 3: Why is the service approach not good enough? (SQ3)

We collected data from the potential users to indentify the improvements and limitations on our proposed service approach. Again, as similar as in phase 1 (see Section 5.2,), we have applied individual interviews in this study. It is also qualitative based, semi-structured. 14 potential users have taken part in, and included students, lecturers and e-learning staff across the University of Warwick. They had all been involved with the second phase of this experiment (see Section 5.3), hence they have experience with, and understand what the service approach and current approach are about. We asked the following questions during the interviews:

- Which approach did you prefer, and why?
- Why didn’t you like the other approach?
- If you could use your preferred approach in the future, would you use the other again?
- What do you think about connecting all the repositories together in the service approach?
- What do you think about having other e-learning services, for example the e-learning delivering services or marking services?
- What do you think about the e-learning services registry we have introduced in the experiment?

We have also applied similar content analysis procedures to study the benefits and limitations of our service approach. Six stages are involved.

- Stage 1: Generating topics
- Stage 2: Collecting quotations to support each benefit and limitation
- Stage 3: Interpreting the quotations to describe each fact
- Stage 4: Comparing the benefits against with the weaknesses in current practice
- Stage 5: Classifying the limitations of our service approach
- Stage 6: Validating the findings

Stage 1, 2, 3, 5 and 6 are more or less the same as the procedures we have applied in Section 5.2. In stage 4, instead of classifying the problems in current practice, we compared the benefits of our service approach with the weaknesses we have discovered in current practice. This allows us to better measure the improvements and limitations of our service approach.

5.4.2 Improvements of the service approach

Evidence from the user feedback indicates that 13 out of 14 people prefer the service approach. The qualitative evidence we have collected from interviews indicates that the service approach can bring a number of benefits to potential users. After participants have taken part in the simulation in phase 2 – discovering e-learning materials for a given topic from a number of popular repositories – they were given an opportunity to express their views on the following themes.

Theme 1: Discoverability

Description of resources allows people easily and quickly to know what they can do about them, and decide which one to use without trying them. In the experiment, description of repositories also allows users to exclude unwanted repositories quickly. Most people agree that the service approach has provided more information, such as 'subjects, languages and so on' to describe each repository, since it is easier for them to know what they can do about, and 'decide suitable repositories to use', and 'exclude unwanted repositories quickly'. Some respondents mentioned the ratings as being helpful since they '… could easily click the best one, and avoid the other ones.' Specific mention was made of the importance that materials should be relevant: For example 'In the past, I don't know which repositories I should use until I have tried them, but now, I could quickly exclude MathWorld as lots of things are irrelevant'.

The second improvement of the service approach is the categorisation of resources, it allows people to discover the tools they want conveniently, and most users even do not know these resources exist at all. Several participants expressed clear support for the service approach, because 'the structure is better as it is hierarchical' and 'the principle of having everything together is good', '… it has stated the goal clearly to me, it helps me to go to the right place more easily.' Another user has also argued that, 'sometimes people don’t know these e-learning tools exist; this approach allows them to discover the software they need’. Another commented ‘I like the layout, you don’t take lots of information, you are actually going to take more information on the things you are interested in.’ One user has stated that ‘now you have so many places to look for information, and get lost easily, I think you can use this first to identify places you feel comfortable with, and then you could just target these places to get information that would be useful for you’.

Theme 2: Interoperability

The service registry gets everything together as a start point, all the resources are linked. It is then quicker and easier to discover the resources people need. While searching the e-learning materials in many repositories, the service approach is more convenient to compare and to look for the most appropriative things, ‘it takes you less time and clicks to perform the same task’. Most people like the service approach because ‘it is convenient and easy to search’, ‘people don’t need to go to, or jump back to each repository one by one’, it also ‘save time to learn how to use each repository’, and requires ’fewer clicks to get the same amount of search results’. Another further identified how the service approach ‘... shows all the results in a single list’, and this was reinforced by a third participant who noted that, when using the current approach, he could not compare the results easily as he needed to consult different lists repeatedly. A user stated that ‘I prefer it because I can quickly discover and scan search results, and quick to look for the most appropriative things’.

Theme 3: Reusability

Service approach allows first time users to know what to do easily without too much learning. 9 out of 14 people believed that, from the user’s point of view, service approach can bring more choices to them, they can get access to more materials which interest them, and this allows for more personal flexibility, as the results, they are more motivated to use and reuse more materials in the future. One participant has noted that ‘if I am looking for something new, I will definitely use this approach’, ‘People are used to use the repositories they are familiar with, or the ones they have been asked to use, the service approach gives them more choices, we like to have choices.’ One user commented that ‘I like this idea, I think in terms of learning, you need plenty of choices, because we are all different’, for example, ‘if you have different types of assignments, you could use different marking services’.

Additionally, Individuals do not have to develop new materials from scratch, as they can ‘reuse or modify discovered materials to suit their needs’, and this could ‘save their time, cost’ and other human effects. Half of the volunteers have addressed this.

5.4.3 Limitations on the service approach

Again, current version of the ST is not perfect. Participants during the interview have suggested that the following improvements are required.

Theme 1: Discoverability

Current version of resources description needs to be improved. More information are required on peer reviews, ratings, user types, minimum IT skills, accessibility of each resource and so on.

3 people commented that more information on peer comments and ratings were requested, including ‘information on how popular each item of material is, how many people have used them before’, and ‘who these users are, how reliable are they’, and ‘what each one’s strong bit is’. Another user has expressed that ‘I think it is better to have more information on why they like it or dislike it’, as we ‘prefer to use the

resources that the other people like, and other people believe are good.' A further suggestion was to add information on which materials each user should use, by considering users' roles, level of IT skills, and accessibility of each resource. For example, 'Maybe you could have different services for students or teachers' and 'you could also classify them as beginner level or advance level'. One user commented that 'I guess that would be a good idea if you have a series of checks on what level of tools, types and formats they are'. We have many tools available, but not many staff have the capabilities to use them, another user has also suggested that 'you could also include whether the link is accessible or not, if it is not accessible any more, then we wouldn't open it anyway'. Although not directly relevant to the approach, the 'look and feel' of the tool was perceived as significant. There were suggestions for more images such as logos or symbols, and fewer texts to describe repositories. For instance, 'I think it is too wordy … people don't like to read that much text … I think the description needs to be shorter'. This may help to explain the responses to the questions which related to clarity. 'I think it is a good idea to have different descriptions for readers if they have 5 minutes, 3 minutes and 1 minute to read. If you only have one minute, how can you tell somebody your information'. Additionally, another user has also commented that, depend on the context, it would be useful if 'there are additional information provided on request, rather than automatically provided to everyone.

Theme 2: Interoperability

Service approach can be improved if different types of services can been linked together, for example, learning materials that have been discovered can be shared and reused easily in learning delivery service later on. One user has also mentioned the feature of linking other e-learning tools together, 'I think services would have to be associated, for instance, services to search e-learning materials, and to run e-learning materials could cooperate together, however, the marking services can might not be fixed in, that is my view'.

Theme 3: Reusability

The interview analysis suggests that our service approach have limitations on the certain types of users. 6 people have mentioned that experienced people who already know which repository they are going to use might not fully benefit from the service approach. No all the people intent to try new tool, in particular staff who are busy and do not have time to do so. In fact, some people do not have the choice at all in practice, as they have been forced to use the e-learning tools they are using now by their own universities or companies, 2 staff have addressed this. Furthermore, users might not be able to see the added value of sharing e-learning resources at all.

5.5 Discussion

Findings

Table 5.5 below compares the qualitative evidence we have collected in different phases in the experiment, in terms of the weaknesses in current approach, improvements and limitations on the service approaches.

As we have mentioned throughout the whole thesis, resource description for current educational applications are poor. We argue that our service framework does solve this by (1) collecting a comprehensive set of e-learning resources together, (2) re-distributing them based on each resource's features and the users' requirements, and (3) connecting them and presenting the similarities and differences between them clearly for varied types of users. However, the current version of the service prototype is not yet good enough as users expect more data to describe the shared resources, and this study has also suggested what other data they are interested in (see Table 5.5a below).

Table 5.5a: Comparison between current approach and service approach

Themes	Weaknesses in current practice	Improvements of the service approach	Limitations on the service approach
Discoverability	Current learning resources are often poorly described and indexed by the providers	Description of resources allows people easily and quickly to know what they can do about them, and decide which one to use without trying them	Current version of resources description needs to be improved. More information are required on peer reviews, ratings, user types, minimum IT skills, accessibility of each resource and so on
	As beginners, users do not know where the materials are, many repositories have not been aware by many people	Description of repositories allows users to exclude unwanted repositories quickly	
	Educational resources have not been well organised, it is difficult to compare them. People cannot choose between different e-learning resources easily	Categorisation of resources allows people to discover the tools they want conveniently, and most users even do not know these resources exist at all	
Interoperability	Current sharing of learning resources is not enough	The service registry gets everything together as a start point, all the resources are linked. It is then quick and easy to discover the resource people need, and users don't have to go to, or jump back to each resource one by one.	Service approach can be improved if different types of services can been linked together, for example, learning materials that have been discovered can been passed easily in learning delivery service later on.
	People cannot access to each e-resource easily since their user interfaces differ substantially	While searching the e-learning materials in many repositories, the service approach requires fewer clicks to get the same amount of search results	
	Most resources can't be accessed remotely, it is common for most tools to rely on different technologies, firewall and format are the main problems	While searching the e-learning materials in many repositories, all the search results are presented on a single list in the service approach, it is convenient to compare and quick to look for the most appropriative things.	

Table 5.5b: Comparison between current approach and service approach

Themes	Weaknesses in current practice	Improvements of the service approach	Limitations on the service approach
Reusability	People don't want to try the latest e-learning technologies, as learning to use new tools is painful for even experienced users	Service approach allows first time users to know what to do easily without too much learning	Experienced people who already know which repository they are going to use might not fully benefit from the service approach
		Service approach can bring more choices to the users, as tools they are using now might have limitations	
	People are not willing to share and reuse other e-resources, as they can't see the benefits of doing so	People are able to try something new, to get access to more resources which interest them	In practice some people have been forced to use the e-learning resources they are currently using, by their own universities or companies, hence they do not have choices at all
		people don't have to develop new resources from scratch, as can simply reuse existing ones	

Related work

Many people from both industry as well as research communities have attempted to develop reusable e-learning materials and repositories in which to store them and make them accessible. These repositories have collected quality learning materials from different subject areas, and contain material written in different languages. However, it is challenging to discover appropriate materials from these repositories, since each repository has a different user interface and the search facilities operate differently. Researchers have tried to improve this, for instance Curlango-Rosas *et al*. (2009) have proposed a tool to provide extra information (metadata) to describe each item of material, in order to support the searching of web based e-learning materials though a number of popular repositories, such as Merlot and ARIADNE. Nevertheless, their work has limitations as the searches apply to individual repositories and thus users cannot perform searches on all repositories simultaneously.

Work has been done to apply service principles in e-learning as well. Although there are proposals for systems, there is little discussion on implementation and evaluation of those systems. For example, Ren *et al*. (2010) have developed a high-level platform to share educational resources in general by following the Web service standards, however their approach has not yet demonstrated how to share resources in practice (in particular the sharing of e-learning materials), nor has it yet been evaluated.

On the other hand, some researchers have explored e-learning services in depth, but their works lacked wider applicability. For example, Chang *et al*. (2008) have developed and implemented a learning contents providing service which is able to rank the search results for different users. The shortcoming of their work in our context is that it has not covered the sharing of other searching services, and it lacks feedback from potential users.

The novelty of our solution lies in a) addressing not only the problem of providing descriptions of learning resources, but also linking those resources together, and b) providing objective, evidence-based views on how to share current educational resources by using service technology. Our findings from experiments 2 have provided direct evidence to support sharing benefits that other experts has discussed. For example, in a JISC's institutions' development report, Rothery (2008) predicted that sharing can bring benefits on 'saving time and cost by reuse', 'making better quality resources available'. He has also mentioned that current learning management systems or repositories are excellent to create and store reusable e-learning contents. However, they are not really designed for sharing. This case study suggests that our service solution offers much greater potential to support this.

Our service solution also has potential to cope with problems in sharing e-learning resources. A number of technical and educational issues in sharing e-learning resources are mentioned in the literature, such as the technological needs to enable resources discovery, improve users' interfaces, educational needs to ensure resources are findable and used appropriately (Charlesworth, 2007), and so on. Our work has provided a successful approach to deal with them.

Methodology

We have applied qualitative 'purposeful sampling' rather than quantitative 'random sampling' in experiment 2. 7 current academic staff have been invited for interviews in phase 1, to discuss how well e-learning resources have been used and shared, in particular the problems they have in current practice. In phase 3, 14 members of staff and students have contributed. Staff are from Education, Computer Science, the distance learning programme in the Business School and the University e-learning support team. Students who participated were studying either in the domain of science, social science or arts, at the level of undergraduate, masters and PhD. These were selected not only because of the e-learning experience they have had during their studies and work, in particular with managing, creating, using and sharing of e-learning resources, but also because they were interested and willing to try something new in e-learning. These people are able to provide more useful information and might better help us understand the phenomenon of sharing e-learning materials using both approaches in-depth. We have used interviews in phase 1 and 3, as it is more appropriate to ask flexible questions and receive detailed responses compared with questionnaires (Miles and Huberman, 1994).

In phase 2, in order to reduce possible threats to internal validity, we use two exactly the same questionnaires to evaluate the usability of each approach, we made sure all materials used for both approaches were the same, and we made sure half of volunteers started from each approach.

As we have maintained earlier, our proposed service approach also has the potential to share other educational resources, such as learners' information, assessment materials and so on. Due to the limitations on time, cost and human resources, we cannot implement the share of all these resources in this case study. Only small number of participants are involved. This is still valid, due to the qualitative nature of our research. As we are interested in information on 'how well' e-learning resources have been shared, and will be shared via services, and we have contributed to knowledge by providing an 'in depth' description of the phenomenon on sharing e-learning resources (Cohen, 2005).

5.6 Summary

In this chapter we have evaluated our novel service approach to share and reuse educational resources via a case study. Most users who took part in our experimental evaluation preferred our approach to the ones available within e-learning today. The evidence we have collected from experiment 2 suggest that our service approach allows users to more quickly and effectively discover e-learning materials than can be done using current approaches. Hence, hypothesis 1 is supported, and hypothesis 2 is partially supported. Additionally, sub questions 1, 2 and 3 are answered as well. Using the ST tool to share current e-learning materials can bring other educational and technical benefits. However, further usability improvements are required, in particular in describing and categorising current e-resources, as the current version of the ST tool is not perfect, we might need to introduce new policies or strategies to attract more people to share and reuse e-learning resources in the future. Hence, research question 4 is answered.

RQ 4: Has the sharing of educational resources been improved via our services framework?

The success of sharing e-learning materials in this case study suggests that our service approach, in particular the Educational Services Architecture we have proposed, has the potential to minimize the expense to develop educational resources and maximize the benefits of using and reusing current educational resources (Yang and Joy, 2011b).

Chapter 6

Experiences on Developing

Educational Services

This chapter reports our experience with developing part of our services framework – the educational services. We have considered plagiarism services JPlag and Sherlock as typical examples throughout the chapter. The technical challenges we have discovered in this study have also opened up further research directions in the sharing and management of educational resources.

6.1 Introduction

This chapter is guided by research question 5:

What challenges are there while implementing the services framework?

This chapter reports our experience on developing part of our services framework – the educational services. We have considered plagiarism tools JPlag and Sherlock as in this study, but before we begin to discuss the steps required to wrap them as services, in this section we will first briefly outline what JPlag and Sherlock are.

JPlag and Sherlock are both educational applications that support the detection of plagiarism among students' programming assignments. They both support similar operations.

<u>Operation A: Sending submissions to examine</u>

This operation is done by uploading a set of students' files to be compared using a pre-defined directory structure. Users can also define their own detection options as they wish (such as which algorithm they want to apply and so on). However, the pre-defined directory structures, detection options, names of each operation are different between JPlag and Sherlock.

<u>Operation B: Receiving detection results</u>

This operation is done by downloading and viewing the results after the detection processes have been completed. Again, the directory structures that store these outputs, the ways these outputs being viewed, and operation names are different between JPlag and Sherlock.

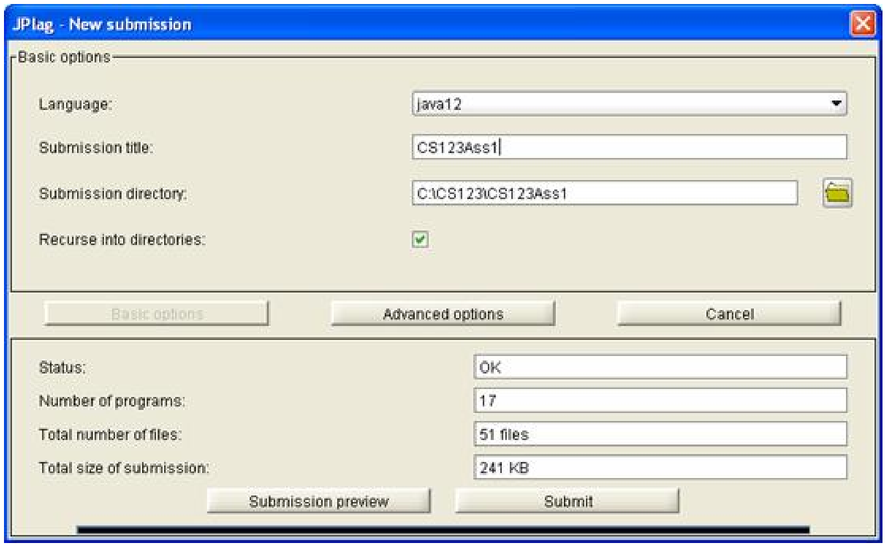


Figure 6.1 JPlag inputs (Source: http://www.ics.heacademy.ac.uk/resources/assessment/plagiarism/detectiontools_comparison.html)

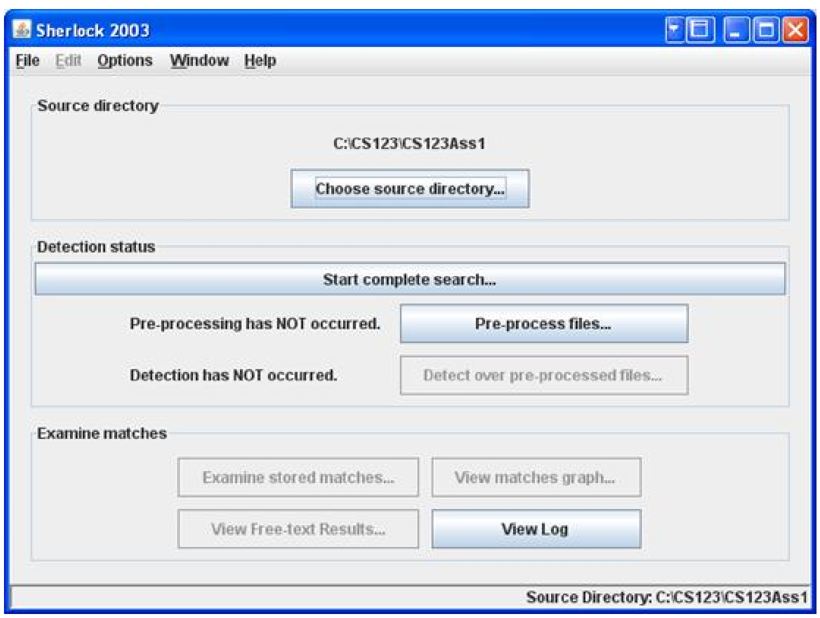


Figure 6.2 Sherlock inputs (Source:

http://www.ics.heacademy.ac.uk/resources/assessment/plagiarism/detectiontools_comp

arison.html)

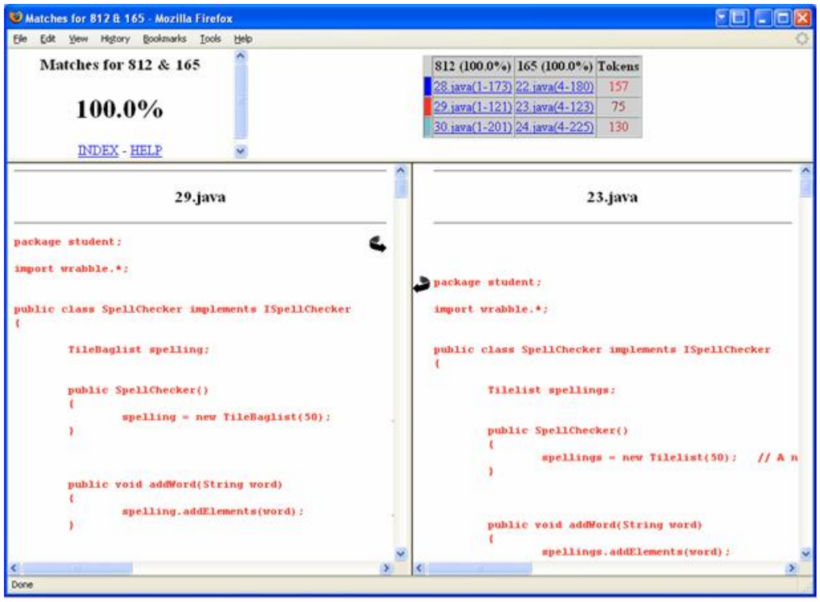


Figure 6.3 JPlag outputs (Source: http://www.ics.heacademy.ac.uk/resources/assessment/plagiarism/detectiontools_comparison.html)

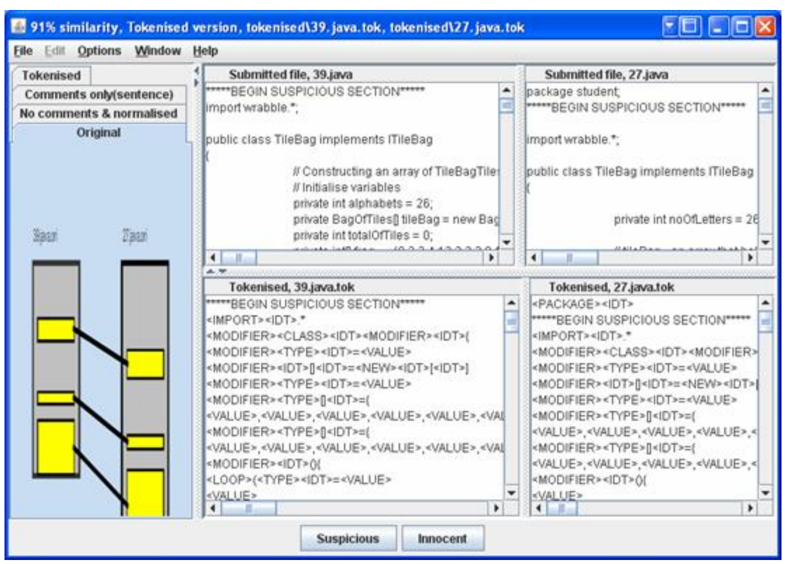


Figure 6.4 Sherlock outputs (Source: http://www.ics.heacademy.ac.uk/resources/assessment/plagiarism/detectiontools_comparison.html)

Development Steps		Challenges at Sherlock Service	Challenges at JPlag Service
Stage 1: Create the educational services	1: Obtain a copy of the source code. A standalone application is used.	Copyright permissions	N/A
	2: Develop the web service class as service implementation. Develop a new class or modify an existing class in the application package, which defines properly I/O data types, together with the methods that handle I/O.	Local coding for data storage and data formats	N/A
	3: Set up the web service developing and runtime environment.	Configuration of compatible external software	N/A
	4: Build this application as a web service, by uploading the service implementation class developed at S2 to the development environment at S3. The WSDL file is then generated, where the I/O operations and exchanging messages are properly defined.	Monitor the performance of each service	N/A
Stage 2: Consume the educational services	5: Create the service client by importing the valid WSDL file of the plagiarism service, and develop the client subs to invoke the service.	Monitor the usage of services	
	6: Use the client subs to contact the server, to retrieve some information from the Service, and then display the results.	Privacy and trusts between remote resources	
	7: Expand the client to invoke other operations in the service, e.g. sending more data to it, and receiving other data from it.	Multiple requests for single service; Low speed in data transmission	

Table 6.1 Steps and challenges while developing educational services

Table 6.1 above lists main steps required to develop JPlag and Sherlock services. The first stage of developing the JPlag service has been completed by the service provider - Karlsruhe Institute of Technology (KIT) in Germany (Prechelt *et al.*, 2000). They have wrapped the local version of JPlag into a web service, and have published its WSDL file at *https://www.ipd.uni-karlsruhe.de/jplag/JPlagService.wsdl*. Users are then able to follow the instructions at their website (JPlag, 2012) and generate their own versions of the service client to invoke the JPlag service. We will explore this at stage 2. In stage 1, the creation of WSDL file is the key achievement for generating educational services, as it indicates that the educational application is online accessible since then, and it has followed the service standards (e.g. WSDL). In this study, we have experienced the development of the Sherlock service and its client at stages 1 and 2, as well as the development of JPlag client at stage 2.

6.2 Challenges during the services development

In this section, we first report the technical challenges we have encountered at each development step from the service developer's point of view. Then we will present possible solutions to address them if there are any from literature and from our own experience.

Step 1: Obtain a copy of the source code. We have used the standalone application (e.g. The Sherlock package in Java) in this case.

Copyright permissions:

In order to convert the educational software to a web service, service developers might need to modify the source code if it is necessary. However, there is no guarantee that they can legally access and modify the software as they wish (Papazoglou, 2012). If the permissions are obtained, for example for Sherlock in this case, service developers are then able to freely extend the source code.

Step 2: Develop the web service class as a service implementation. Develop a new class or modify an existing class in the application package, which defines properly I/O data types, together with the methods that handle I/O.

Local coding for data storage and data formats:

The service provider's data centre (e.g. storage space containing a number of databases) has not been properly set up, hence the data in Sherlock are not easily accessible, and it is not straightforward to indentify and describe Sherlock's inputs and outputs and their data types. Ideally, a Sherlock service should have the following inputs A and B, and should return the output C as below:

Input A: A folder contains student files that need to be examined.

In fact, at runtime, Sherlock only receives the *location* of the folder on the local disk (rather than the actual contents of the folder) from the user, and it then accesses the location and processes the files in that folder. However, in order to convert Sherlock into a proper service, we need to take the actual contents in the folder as input, and should not worry about the location where the folder is stored, as the contents of the folder might come from a remote data storage space from other servers through on Internet.

Input B: A set of detection options pre-defined by each user based on their needs, before each detection job starts.

The possible options are using the ‘Tokenised’ algorithm or the ‘Samelines’ algorithm, whether or not to pre-process the files by removing the comments and white spaces on each line of codes, and so on. The parameters that describe these options are stored in a number of Java objects in Sherlock, such as ‘Settings’, ‘SherlockSettings’ and so on. Furthermore, the values of these parameters might be modified and updated by the users or dynamically by Sherlock itself during the detection process. These make access to the input data even more challenging.

Output C: a set of detection results that explain the similarities between student files if there are any.

Again, the results are not stored in a single place. Depending on how users have selected the detection options at Input B, parts of the outputs are stored in a number of folders on the local disk with varied formats (including types .sen, .ncn, .ori, et al), and the other parts of the outputs are kept in a array called ‘storedMatches’. Hence, it is difficult to package them into a single file (maybe in zip or gzip), and forward them effectively to other software components (maybe to a service client or to other educational services) over the Internet. Additionally, from users’ perspectives, they might wish to view the outputs in different ways, which means not only as plain texts, but also as coloured graphs, tables and so on. To better describe and restructure the outputs at the Sherlock data center is the next step service developers can explore. So that, more flexible Sherlock service clients can be easily built, and they can view the detection results in the varied styles.

In order to address these challenges at S2, we suggest that the Sherlock developers could develop a database as the Sherlock data center. It properly defines and stores the inputs and outputs mentioned above, and possible the other data needed during the detection processes. Developers can then modify the existing class that handler inputs and outputs in Sherlock, we can name it as Service.java for example, as there exist Sherlock.java for the command line version of Sherlock, and GUI.java for GUI version of Sherlock, by inserting the inputs into the data center and pulling out the outputs from the data center. This Service.java class will then be used to generate the WSDL file for the Sherlock service automatically by the service generator at S3. The generator expects that the main Sherlock implementation class should only contain the methods that handle I/O, and each method must have well defined inputs and return data.

Step 3: Set up the web service development and runtime environment. We have used Apache Axis 2 (Web service / WSDL / SOAP engine), Apache Tomcat (Web server) and Eclipse IDE in this study.

Configuration of compatible external software

Certain service development platforms such as some versions of Eclipse Web Tools Platform have compatibility issues with Axis2. Our work is tested with Apache Axis2 1.6.2, Eclipse JUNO and Apache Tomcat Server 7.0 in 2012. The combination of these technologies allows plagiarism services to be generated, tested and running over the Internet (Kalin *et al.*, 2009).

Step 4: Build this application as a web service, by uploading the service implementation class developed at **S2** to the development environment at **S3**. The WSDL file is then generated, where the I/O operations and exchanging data are properly defined. The running service which is deployed by Axis2 is listed on the server (for example at http://localhost:8888/PlagiarismServices/services/listServices). By clicking the link 'SherlockService' on the list, we can then discover its WSDL file.

Monitor the performance of each service

Table 6.2 below compares I/O data handled by plagiarism services Sherlock and JPlag, which are relevant to the operations we have mentioned at section 6.1. They are collected from their WSDL files. Letters *esd* means the data type is predefined by WSDL, where *complexType* means more than one type of *esd* is contained in this data type, and this data type is specified for this particular service only.

JPlag service		Sherlock service	
Name	Type	Name	Type
arguments	complexType	options	complexType
submissionID	xsd:string	detectionID	xsd:string
inputZipFile	xsd:hexBinary	submissionFile	xsd:hexBinary
zippedResult	xsd:hexBinary	resultDetected	xsd:hexBinary
JPlagException	complexType	SherlockException	complexType

Table 6.2 Comparison of I/O data at plagiarism services

As we can see above, only data for plagiarism detection are available. In principle, these should be enough for running the plagiarism services. However, in order to monitor the performance of each service, and thus maximise the benefits these services can bring into the service community, we suggest that extra data, which might be invisible to the users, should be also considered, in particular if people are interested in the management of educational resources. Some researchers have suggested that measuring the time taken for executing each operation within the service, time taken for data I/O, data encoding and decoding, data conversions, and data transfer could help with understanding the efficiency of each service (Owonibi and Baumann, 2010). This information could also be used to support the selection of services, as well as the further service composition (Raj and Sasipraba, 2011). However, it is still unclear what kind of data should be included to evaluate the performance of educational services, and which technical component should implement this, and how.

Step 5: Create the service client by importing the valid WSDL file of the plagiarism service, and develop the client stubs to invoke the service.

Monitor the usage of services

A feature of Web Services is that they are platform-independent and language-independent, since they use standard XML languages. This means that the client application can be programmed in C++ and running under Windows, while the Sherlock implementation is programmed in Java and typically running under Linux.

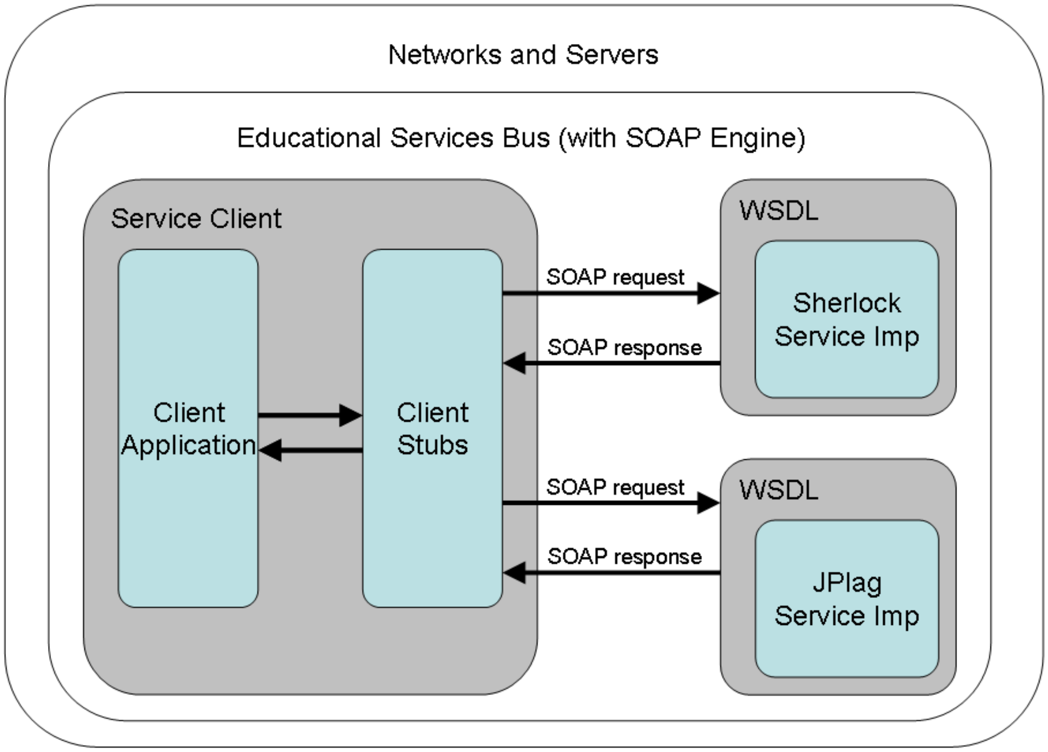


Figure 6.5 Plagiarism services and their clients

After the plagiarism services are built, the *service clients* (programs that want to access the plagiarism detection service) would then contact the *Sherlock or JPlag Service* on the server, and send a *service request* (which contains the inputs in SOAP format) asking for the plagiarism detection results. The server would return the results through a *service response* (also in SOAP). As seen in the diagram (Figure 6.5) below. The client stubs are used to generate SOAP requests and interpret SOAP responses sent from the services, as both the client and Sherlock service implementation are standalone applications, and know nothing about SOAP. That is why we need the SOAP engine, software that can handle SOAP requests and responses. We have included it in our educational services architecture, and have named it as the Service bus (for SOAP messages only currently) in Section 4.2. The client stubs are also real examples of our proposed client adapters, which act as connectors between varied client applications and service implementations. Again, as similar to the challenge at step 4, it is still unclear that what kind of data should be considered, and which technical component should implement this and how.

Step 6: Use the client stubs to contact the server, to retrieve information from the Service, and then display the results.

Privacy and trust between remote resources

At stage J6, we planned to contact the JPlagService via server Glassfish 3.0. However, our Java client can not access JPlag Service either using SSL over HTTPS, or using Service Explorer over the Eclipse Web Tools Platform.

Error message:

javax.net.ssl.SSLHandshakeException: java.security.cert.CertificateException: No name matching www.ipd.uni-karlsruhe.de found

We have indentified a number of potential solutions to cope with this issue. Unfortunately, none of them allows us to get access to the remote service successfully. The details are presented as below.

Attempt 1: add a trust manager

As stated at the JPlag provider website, we can attempt to 'create and install a Trust Manager which does not validate certificate chains' (Source: *https://www.ipd.kit.edu/jplag/dev_java_3_contact.html*), other experts have also recommended the use of Trust Manager for similar issues (Source: *http://jeboyer.wordpress.com/2010/04/12/ssl-how-to-accept-a-self-signed-certificate/*). However, the 'certificateException' has not been resolved after we have applied the solutions they have suggested.

Attempt 2: add a *javax.net.ssl.HostnameVerifier()*method

Java experts have again suggested to add a javax.net.ssl.HostnameVerifier() method to override the existing hostname verifier, hence to fix this problem. For example at (Source:*http://www.mkyong.com/webservices/jax-ws/java-security-cert-certificateexception-no-name-matching-localhost-found/*) or (Source:*http://bluefoot.info/howtos/how-to-avoid-java-security-cert-certificateexception-no-name-matching-localhost-found/*), or (Source:*http://jijo84.blogspot.co.uk/2009/02/javaxnetsslsslhandshakeexception.html*). Again, the 'certificateException' could not be fixed after we have applied the codes they proposed.

Attempt 3: import a self-signed certificate

Another approach was to download the digital certificate from JPlag provider, and then import it manually to our web server, and hopefully the Glassfish will accept it. However, our server considered that the certificate we have gained from JPlag is invalid, and didn't trust it at all (Source: *http://artur.ejsmont.org/blog/content/how-to-generate-self-signed-ssl-certificate-for-glassfish-v3-and-import-it-into-java-keyring*) or (Source: *http://www.sslshopper.com/article-how-to-create-a-self-signed-certificate-using-java-keytool.html*.) or (Source: *http://www.java.net/forum/topic/glassfish/glassfish/ssl-glassfish-having-trouble-setting-it.*) or (Source: *http://grepthelinuxblog.blogspot.co.uk/2012/02/glassfish-ssl-verisign-certificate.html*)

Thus, access to remote educational service is not straightforward. The point we are making regarding step 6 is that it requires advanced knowledge in computer security, in particular in the domain of trust between remote web based applications (Dragoni, 2009; Gollmann, 2011). Beside security, while communicating with remote web based applications, other concerns might be raised as well, including privacy, compliance and reliability. When users transfer their data to the service provider's data center, it is possible that somebody else might have also access to their data. If the data are being kept in a different country, there can also be issues on local laws and control of the data.

Moreover, to date, there are no clearly defined service level agreements offered by service providers (Georgakopoulos and Papazoglou, 2009).

Step 7: Expand the client to invoke other methods in the service, e.g. sending more data to it, and receiving other data from it.

Multiple requests for single service

There is a possibility that multiple service clients are contacting Sherlock for getting detection results at the same time. The communications might be disconnected during the runtime due to the network problems. The Sherlock service might be confused, as current local version of Sherlock can only handle a single request from a single user each time. We suggest that the first step is to generate and include detection IDs in Sherlock implementation, and store these IDs in its data center. Hence, Sherlock knows how many, and which detections it is dealing with at runtime. However, this might request large workloads on programming as the current implementation of Sherlock requires further design and modification.

Low speed in data transmission

In web services, all the data are transmitted in XML, which is obviously not as efficient as using binary code, especially for large amount of data transmission (Zhang *et al.*, 2011). Although service technologies have advantages in portability, they lose in efficiency. Maybe this is acceptable for most applications in principle. However, for the plagiarism services we are using in this study, moving large numbers of student files to a remote service within a limited amount of time may be problematic.

In order to cope with this, Kyusakov *et al.* (2011) have proposed a processor that could convert the text-based XML into binary structured data. Alternatively, Seiler *et al.* (2011) have proposed another approach to transfer data within the services community (Figure 6.6 below).

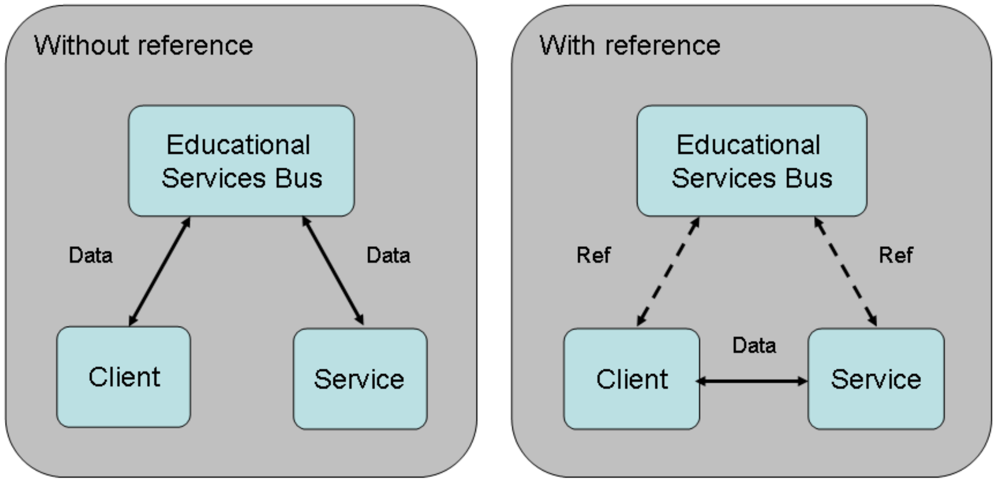


Figure 6.6 Two ways of data transfer

Currently, students' files are uploaded from the service client, and then are transferred to our proposed educational services bus, before they are passed to the plagiarism service for detection. It is clear that, data are transferred twice in this approach. In Seiler's approach, the speed for data transmission is increased significantly. The service client responds a reference to the bus, which in turn sends this reference to the service. After the reference is received, students' files are transferred directly from the client to the service. This approach is also applicable for dealing with services responses to the clients from the services, as well as data transfer between services. However, these ideas have not been implemented to deal with educational data yet.

6.3 Technical contributions on our framework

Our research aims to explore solutions which improve the sharing of current educational resources. We have considered SOA and web services technologies in this study as they represent popular technologies that (at the current time) have potential to support such solutions. This section evaluates the technical contributions of our proposed services framework.

This implementation study has indicated that service technologies do help in terms of supporting resource description and interoperability in our services framework. Users can easily and quickly know what educational resources are out there, and decide which to use without trying them. Technical components within the framework, such as educational services, their clients, the service registry and so on, are also able to know exactly what functions each resource can offer, and how to interact with each one.

We argue that other technical components, in particular the service bus and adapters in our proposed educational services architecture (see Section 4.2), have potential to overcome the following indentified technical challenges. However, limitations remain on most implementation products.

Monitor the performance of each service

We argue that, in principle, a technical component in our proposed architecture – the service bus – is able to monitor service performance. Beside message delivery and data transformation, most current ESB products we have mentioned in section 4.5.3 have stated that they have capability to monitor the operations of connected services, for example the Oracle ESB, Microsoft BizTalk, and Apache ServiceMix. Unfortunately, most of them are not Open Source, and they are designed for business or general purposes only. It is also unclear that what kind of data should be considered for monitoring e-learning services.

Monitor the usage of services

Beside acting as connectors between varied client applications and service implementations, we argue that the client and service adapters should have other capabilities, for example to monitor the usage of services invoked by each client, and perhaps report and notify it to the services community, for further research and commercial purposes. Again, as similar to the challenge above, it is still unclear that what kind of data should be considered for monitoring educational services. Current available adapter products can only monitor business activities, such as the ones from Microsoft BizTalk (see Section 4.5.3 and 4.5.5).

Multiple requests for single service

After the detection IDs are included, the service bus and adapters in our services architecture should also be considered which allocate requests and responses to different clients and services appropriately. This process is also called message/data routing. Some technical products (mentioned at Section 4.5.3 and 4.5.5) have argued that their ESBs and/or adapters can support this, such as the IBM WebSphere ESB, Microsoft BizTalk adapters, Apache ServiceMix, and so on.

6.4 Limitations on service technologies

However, as with many other recent technologies, SOA and web services are neither perfect nor robust. Technical challenges indentified in this chapter have suggested that service technologies have the following weaknesses when used to implement our framework.

As we have mentioned before in Chapter 2, educational resources are not only limited to educational software such as the plagiarism detection tools, but also including storage space for learning contents such as MERLOT, or learning environments that runs these contents such as Moodle. Current service development platforms mainly support the development of web services from existing software applications, and there are not too many guidelines available to support the development of other educational services such as data storage space or learning delivery platforms.

Services technologies allow large amount of structured and unstructured educational data to be shared or accessed externally over the network. However, managing these data is not straightforward. Problems at step 2 and step 4 suggest that, depending on the nature of different educational software, not all of them has been designed or set up properly to support data sharing, some of them do not have their own database, and indentifying and structuring the data to be accessed externally is still not straightforward. There are also challenges in managing data that are passed around within the services community. Abadi (2009) has pointed out that data loss or unavailability could happen at runtime. Additionally, some large resources providers have data centers throughout the world, this might raise challenges such as data format inconsistency at different data centers, data storage at remote and perhaps unreliable locations, data transfer between untrusted hosts (see problem at Step 6) and so on. There is not too much discussion available to cope with these data management concerns in web services.

Currently, web services support only the request-response style of interaction between the clients and resources, with only four message exchanging patterns: Input-Output, Input-Only, Output-Input, and Output-Only. This is reasonable in the web based world. However, nowadays, the user interfaces are not only limited to the web browsers, two dimensional displays. Touchscreens, popup windows, color highlighting are increasingly attractive to common users and new start ups. The change of clients' interaction needs has increased the difficulties 'to design in details every mode of interaction for every application and platform imaginable' (Cerf, 2012; Richards *et al.*, 2012).

Finally, there are also shortages in resources management. Although some services experts have suggested potential approaches to address this (Georgakopoulos and Papazoglous, 2009), there is still not a commonly agreed data standard that has been mentioned to record and monitor the performance and usage of each educational resource. As we have discussed in Step 4 and 5 in Section 6.2, information could be considered to include how often each resource has been used, by whom, how well the resources have performed over time, and whether they are still available, up to date, accessible, trustable and so on. In terms of supporting technologies, some of current service bus products, such as the Oracle ESB (see Section 4.5.3), support the visual representation of service relationships, management and monitoring of services operations, however, they are commercial and designed for only general or business purposes.

6.5 Summary

To summarise, our proposed educational services framework is valid to support the resources description, discovery and monitoring. However, having considered web services and SOA in our educational services framework is the initial stage for improving the sharing and reuse of current educational resources. Our service development experience and literature reviews have suggested that a number of challenges still remain to implement our services framework, especially for resource development, data management and web accessibility among indentified educational resources:

- To share more complicated types of educational resources such as e-learning environments or platforms, and e-learning data storage spaces;
- To better structure and manage data are shared and accessible within the services community;
- To improve the resources' accessibility by considering privacy and trustworthiness

within the community, as well as considering more interaction styles between varied users and resource providers;

- To better report and monitor the performance and usage of connected resources as a group and as individuals, in order to create more research and commercial values via sharing educational resources.

We suggest that to improve the sharing of educational resources further should not only consider web services technology. According to literature surveys we have conducted throughout this research, until the end of 2009, there were few extra features or potentials which had been added to current web services technology, in particular none addressed the challenges we have discovered above. Alternatively, cloud computing and its cloud services, have become more of interest in academia and industry since then. Some experts even argue that cloud computing has potential to develop data storage services and platform based services, as well as to improve data availability and durability within the community (Abadi, 2009; Rafique *et al.*, 2011; Sitaram *et al.*, 2012). However, this technology has not fully matured yet (Ma and Zhang, 2012), it is hard to predict now how far cloud services can go, how many challenges and how well this technology can actually cope with, and whether or not other novel technologies will replace it and when (Rittinghouse and Ransome, 2010; Moyer, 2011). The study of cloud technology is out of scope of this PhD research.

Chapter 7

Conclusions and Future work

This thesis has explored a solution – an educational services framework – to improve the sharing of e-learning resources in higher education by applying the latest service technologies. Our findings suggest that this framework is effective to deal with both technical and educational limitations in resource discovery, interoperability and reusability, but a number of technical challenges still remain on implementing the framework, in particular in resource development, management and accessibility. This final chapter concludes our work, summarising our research achievements and contributions, identifies the limitations, and suggests future research directions.

7.1 Achievements

Our research has the following achievements.

Approach to indentify educational resources to share and reuse

This thesis has proposed a novel and detailed approach to identifying e-learning resources that could be shared in a typical educational institution (Chapter 3). The novelty of our approach relies on 1) applying the concept of *educational services* to match users' requirements with available software applications that support e-learning, and 2) introducing the idea of *data flows* between services, in order to allow e-learning data to be shared. The approach required three phases to identify shareable e-learning resources. The first phase was to identify distinct learning and teaching processes from a case study, using staff interviews and literature reviews to collect data. The second stage was to identify data flows within and between these processes using a qualitative data flow analysis. The final phase was to abstract e-learning services based on those processes and data flows. Hence, people can easily map current available e-learning applications with services indentified, if it is necessary. To our knowledge, this is the *first* approach to indentify e-learning services for the purpose of sharing current educational resources, where the idea of data flows is considered.

Educational services architecture to improve the sharing

Our research has also proposed a novel educational services architecture to share e-learning tools and data by using the latest service technologies (Chapter 4). The architecture contains elements including service bus, service registry, data converters and adapters. The cooperation between these elements has potential to improve the sharing of e-learning resources, as it allows resources to be better described, structured, and connected, by following the principles of discoverability, interoperability and reusability in service technologies. The novelty of our work lies in 1) that compared with transitional SOAs for business purpose, our architecture features data converters to further process educational data and service / client adapters to smooth the connections between educational resources, and 2) our architecture allows the resources required at all stages of the e-learning process to be shared and reused, and the potential users are not limited to learners and educators.

Collection of sharing experiences from services users and developers

The effectiveness of our educational services framework is evaluated based on users' experiences, through a case study at a typical UK educational organisation – University of Warwick (Chapter 5). During the experiment, we compared users' experiences on the sharing e-learning contents with and without our service approach. Part of our service framework was implemented via simulation prototypes to support this experiment. The positive and negative feedback we have gained from the activity have suggested that our service approach, in particular the Educational Services Architecture we have proposed, has potential to allow users to more quickly and effectively discover e-learning materials that suit their needs, than can be done using current approach.

Our educational services framework was also evaluated from services developers' point of view. We conducted a case study to implement two plagiarism detection tools as educational services (Chapter 6). This experience has indicated that these technical components within the framework (or our proposed architecture) are reasonable to support the sharing of educational resources. However, a number of (substantial) technical challenges have been encountered during the services development, which have also suggested limitations on web services within our framework.

7.2 Contributions

Our research has the following theoretical and practical contributions.

Address limitations in sharing educational resources

The literature survey (Chapter 2) has indentified a number of educational and technical limitations in sharing educational resources, including the lack of awareness of current e-learning resources and the lack of interoperability between most educational resources. Our user interviews from experiment 2 (Chapter 5) has also indentified that in current practice resources description and connection should be improved.

The research outcomes from experiment 2 (Chapter 5) have suggested that our framework has potential to improve resource description and connection, as our service prototype (partial implementation of our service framework) has, from the users' perspective, effectively described, compared and connected sharable resources as a group. The findings have also suggested that users expect more data to describe current resources. The implementation of educational services in Chapter 6 has suggested that SOA and web services technologies are able to technically address the limitations on resource description and connection, however, there are still technical challenges remaining which relate to resource development, management and accessibility while implementing our service framework.

Address knowledge gaps in sharing educational resources

Our work has defined and reviewed current e-learning tools, systems, platforms and their relevant data as education resources, and has investigated how well they have been shared. We have also developed a solution – our educational services framework – to improve the sharing in current practice. This framework has been evaluated from the users' and services developers' perspectives.

We have explored possible resources to be shared as a university level. We have also presented the connections between these resources from users' requirements angle, where the idea of data flows to abstract the resources has been considered. These have not been conducted before in the e-learning community.

We have also conducted a study to wrap e-learning tools as services, and have reported a number of technical challenges we have encountered. These findings have indicated limitations on web services for supporting the sharing of educational resources in our framework. Again this task has not been performed before in e-learning services community.

Improve practice

The success of our case study in experiment 2 (Chapter 5), which uses services to share e-learning materials, suggests two benefits. 1) A better idea to reuse e-learning resources – instead of developing new materials from scratch, we could easily reuse or modify existing quality materials discovered from our proposed Educational Service Architecture. 2) A better approach to share e-learning resources – instead of searching e-learning resources using a search engine, our proposed Educational Service Architecture provides a platform to organise and publish existing resources, and connect them together, which is able to meet different users' needs more effectively.

Improvements we have indentified from experiment 2 have also suggested that policy makers, such as government workers and educational administrators, may encourage the sharing of e-learning resources between institutions and nations, as our service approach, in particular the educational services architecture we have proposed, has potential to minimize the expense to develop educational resources and maximize the benefits of using and reusing current educational resources.

7.3 Limitations and further work

This section summaries the limitations of our research in previous chapters, and introduces various interesting areas for future research.

The first limitation is about the scope of our experiment 1. We have conducted a case study to indentify e-learning resources to share, however the experiment data we have collected are based on a single case study within a typical UK university only. Evidence to support our proposed approach would be strengthened and more reliable if we could apply two or more case studies in other universities, but this raises issues of replication of data and of the difficulty of obtaining (possibly confidential) data from other institutions. This raises an open question:

What is the impact of applying our proposed approach to indentify e-learning resources in other educational organisations?

During our research, we proposed a services framework to enable the sharing of our indentified e-learning resources. Due to the limitation on time, human resources and technical support, we have only implemented part of our services, data flows and architecture in the framework in experiment 3. In this case study, we have only focused on the sharing of e-learning materials in a number of popular repositories, in particular discover, comparing and selecting useful e-learning materials from a number of resource providers. This leaves the following open question:

How effectively can other e-learning resources, other than e-learning materials, be shared by our proposed framework?

Findings from experiment 2 have also suggested limitations on current version of our service tool, although our proposed services framework has potential to cope with some, however, the following questions remain open:

How to remove management barriers that prevent the sharing of current e-learning resources, such as copyright, language, and financial issues?

How to improve the descriptions of current e-learning resources?

How to improve the categorisation of current e-learning resources?

Another limitation was the sample size for experiments 1 and 2. Due to the qualitative nature of our case study, only limited amount of academic and administrative staff contributed, and there has been no survey, historical or ethnographic research included in our experiments. This raises the question:

What is the impact of applying our proposed framework to share e-learning resources across many educational organisations globally?

During our study, we have identified a number of technical challenges and gaps to support varied aspects on resources sharing, and these leaves the following questions open:

How to separate or recombine current e-learning applications to better map with our identified services?

How to wrap e-learning platforms or e-learning data storage spaces as educational resources which are accessible online?

How to expend current standards to represent and structure e-learning data, such as course information, learning performance and learning plans, which are shared and *accessible within the e-learning community?*

How to expand current standards to process e-learning data, and hence support the development of data converters in our proposed architecture?

How to develop data standards to monitor the usage and performances of connected educational resources?

How to improve the resources accessibility, by considering privacy and trustworthy within the community, and by considering more interaction styles between varied users and resource providers?

In this research, we have only applied web service technologies to support the sharing of e-resources, due to the nature of rapid development in computing, cloud computing might be the future option to support the sharing of our indentified resources. This raises the open question:

What is the impact of applying other technologies in our services framework to better share our indentified e-learning resources?

Finally, for people who are interested in our research:

How to encourage more people to share and reuse e-learning resources?

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Appendix

Materials for experiment 2

In this section, materials used during experiment 2 are given. Part 1 summarises what this experiment is about, and users read through it before the experiment took place. Parts 2 and 3 were used during the experiment, where part 2 explains the tasks each user should conduct on the day, part 3 records the user's experience with both approaches. The usability questionnaire is exactly the same for evaluating the first and the second approaches.

- **Part 1: Experiment introduction**
- **Part 2: Activities on experiment day**
- **Part 3: Materials for the first and second approaches**

Part 1: Experiment introduction

Background

Today a lot of good quality e-learning software has been developed. They are widely used to cover varied aspects of learning and teaching activities, such as developing learning materials, delivering learning activities, and performing assessment tasks. However, people cannot fully benefit from these valuable resources as they are often not shared effectively and efficiently.

In order to cope with this, we have proposed a new approach in our research. Currently, we are very interested in finding out how effective this approach is. We would like to have some feedback from you in this experiment.

A repository is a database which collects information on reusable learning materials that is available via the Internet. You will be able to query the repository, and view a number of materials about a topic that interests you.

Experiment activities

On the experiment day, you will carry out the following activities:

- Search and choose e-learning materials for a given topic from many repositories by using the *first* approach
- Search and choose the same e-learning materials again, by using the *second* approach
- Have a 15 minutes discussion on both approaches you have just used

Part 2: Activities on experiment day

Today we would like to discover your opinions on using two different approaches to discover and choose e-learning materials from a number of repositories. We expect you to perform the following activities.

Task 1: Search and choose e-learning materials for a given topic from many repositories, and note down what you have found, and fill in a short questionnaire to record your *experience* on the first approach. Please refer to **Materials for the first approach** to start with.

Task 2: After you have attempted the first approach, please conduct the second approach and refer to **Materials for the second approach**. Search the same e-learning materials again, and record what you have found, and fill in another questionnaire to record your *experience* on the second approach.

Task 3: Finally, we are going to have short discussion on the approaches you have just experienced. The main topics we are going to discuss are listed below.

Interview Questions

- Which approach did you prefer, and why?
- Why you didn't like the other approach?
- If you could use your preferred approach in the future, would you use the other again?
- What do you think about connecting all the repositories together in the service approach?
- What do you think about having other e-learning services, for example the e-learning delivering services or marking services?
- What do you think about the e-learning services registry we have introduced in the experiment?

Please note that, there are no right or wrong answers in this experiment. We are only interested in your opinions on both approaches you are going to experience with.

Part 3: Materials for the first approach
(Materials for the second approach)

Begin by visiting the page ‘Collection of E-learning materials repositories’. Please search e-learning materials for the topic ‘**Essay writing**’. Search this topic from all the repositories and write down the **2** pieces of materials you **like the most**. This is a personal preference based on the content of the materials.

Step 1:

- **ID** of the **first** e-learning material I like most is:
- **ID** of the **second** e-learning material I like most is:

Step 2:

Please circle the option that seems most accurate to you. Choose only **one** answer for each statement. Record your **immediate response** to each statement, rather than thinking about it for a long time.

1. This approach allows different repositories to be searched easily.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

2. This approach allows search results to be well displayed.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

3. This approach allows users to understand each e-learning material quickly.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

4. This approach allows users to choose useless e-learning materials quickly.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

5. This approach is able to show the differences between all the repositories accurately.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

6. This approach allows users to access all the search screens easily.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

7. This approach allows users to choose useful e-learning materials easily.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

8. This approach is able to clearly describe each repository.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

9. This approach allows users to decide which repositories to use easily.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

10. This approach allows user to find out the quality of discovered materials easily.

A: Strongly Disagree B: Disagree C: Neutral D: Agree E: Strongly Agree

Finally, if you have anything further to add, please comment below.